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The American Midland Naturalist

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THE SKULL OF LEIDYOSUCHUS CANADENSIS LAMBE*

C. M. STERNBERG

INTRODUCTION

In 1908 the late L. M. Lambe,[1] then vertebrate Palaeontologist of the Geological Survey of Canada, described a new genus and species of crocodile from the Belly River formation (Pale Beds) of Alberta under the name *Leidyosuchus canadensis*. This species was established on the left mandibular ramus from the badlands on Red Deer river below the mouth of Berry creek (Steveville, Alta.). He also included, as cotypes, several portions of skulls and jaws, teeth, vertebrae, and scutes. At an earlier date[2] Lambe had referred the teeth to *Crocodilus humilis* Leidy and the cranium to *Bottosaurus perrugosus* Cope.

In 1910 Mr. C. W. Gilmore described a new species of crocodile, which he referred to Lambe's genus as *L. sternbergii*. Gilmore's type which consisted of a fine skull and jaw, came from the more recent Lance formation of Niobrara (Converse) Co. Wyoming.

In 1917 the writer collected an almost complete right mandibular ramus, of *L. canadensis* (Cat. No. 2784, Geol. Surv. Can.) from the same general region and horizon as that from which Lambe collected his types. This specimen is consid-

[1] Trans. Roy. Soc. Canada, Sec. IV, Vol. I — 1908, pp. 219-244.
[2] Cont. to Can. Pal. Vol. III (quarto) Pt. II, 1902 — pp. 47-48.
[3] Pro. U. S. Nat. Mus. Vol. 38, pp. 485-502, Pls. 23-29.
* Published with permission of the Director, Geol. Survey of Canada.

erably larger but otherwise does not differ materially from Lambe's type.

While working in the same region in 1928 the writer collected a fine skull of *L. canadensis* (Cat. No. 8543 Geological Survey of Canada) from about three miles southwest of the mouth of Berry Creek. It came from the Upper part of the Belly River formation about 125 feet above the level of Red Deer River and consists of an almost complete skull with thirteen teeth. It is splendidly preserved and most of the sutures are easily traced. The back of the skull had washed out before discovery and some parts were lost so that it was necessary to restore the occipital region, the brain case, part of the posterior half of the right side, the left post-orbital bar, and a considerable part of the pterygoids. These restored parts are made of light colored plaster and are easily distinguished in the illustrations (Pls. XV and XVI).

The mandibular ramus (No. 2784) is essentially the same as Lambe's type except for size, and there is no doubt but that it represents the same species. The skull (No. 8543) shows the same type of teeth as the dentary and corresponds with Lambe's cotypes and there seems to be no question but that it represents the same species. Additional specific characters can, therefore, be given for *L. canadensis* from the new material particularly the skull.

Leidyosuchus canadensis Lambe.

Gilmore has characterized the genus (loc. cit. p. 500) quite fully and only a little can here be added. The revised list of generic characters will, however, be included here.

Generic characters: cranium short and of moderate breadth; frontals contributing to boundary of supratemporal fossae; prefrontals not in contact with maxillae; nasals almost or quite reaching external nares, external nares broader than long; premaxillary aperture moderately large; palatal aspect of premaxillae slightly lengthened with posterior border convex and indented medially by the anterior processes of the maxillae; posterior nares wholly enclosed by pterygoids and located about their middle; orbits

much larger than lateral temporae fossae; mandibular symphysis short and contributed to by splenial; upper teeth more numerous than lower; first lower tooth received into a pit in premaxilla and third and fourth into a notch in premaxilla and maxilla; third and fourth lower teeth subequal; fourth and fifth maxillary teeth enlarged, subequal; vertebrae procoelian; dorsal and ventral armor.

Specific characters: Preorbital portion of skull relatively long; anterior half of preorbital portion relatively broad; maxilla-premaxillary notch sharply defined; superior surface of maxilla ending squarely in front; snout broad; premaxillary aperture large, elongated; posterior angle of palatal portion of premaxilla acute; anterior tip of palatal plate of maxilla reaching to premaxillary aperture; palatal portion of maxilla elongated; palatine forming whole of internal margin of posterior palatine vacuity; teeth subcircular in cross section, larger ones with transverse diameter greatest.

SKULL

When viewed from above the general outline of the skull (Pl. XV) more nearly resembles that of *Crocodilus porosus* than that of *L. sternbergii.* The preorbital length is more than two-thirds that of the total length of the skull whereas in the Lance species it is barely three-fifths of the total length. It is less triangular than Gilmore's species due to the broadening opposite the fourth and fifth teeth and the broad snout. A second representative of *L. sternbergii,* figured by Gilmore, (loc. cit. Pl. XXVIII) is broader in the facial region than the type. Gilmore accredits this to greater age and individual variation. The specimen before me is still broader yet the open sutures would suggest that it was less mature than either of the representatives of *L. sternbergii.* The greater preorbital length is also a character which is associated with greater age as shown by Mook's study of "Individual and age variations in the skulls of recent Crocodiles."[4] One might surmise, therefore, that an old individual

[4] Bull. Amer. Mus. Nat. Hist. Vol. XLIV, Art. VII, 1921.

of *L. canadensis* would show even a greater difference from *L. sternbergii,* than does the present specimen.

The skull is almost flat on top but with a slight upturning of the snout. All of the top of the skull is well ornamented with moderately deep pits varying from circular to irregularly elongated depressions. These pits are well defined and separated by very narrow ridges but there is no definite arrangement in longitudinal or transverse rows. They are most pronounced on the frontals and jugals. On the anterior tonge-like process of the frontals, which extends forward between the prefrontals and nasals, the pits give way to longitudinal ridges and striae. The sculpturing on the parietals appears to have been similar to that on the parietals of *L. sternbergii* but these bones are not complete in this specimen.

SKULL FENESTRAE

The supratemporal fossae are subcircular in outline and smaller than in *L. sternbergii* but as there is some restoration in this region these characters may not be altogether dependable. The internal half of the anterior border of the supratemporal fossa is formed by the frontal. From the study of a disassociated frontal Lambe believed that that bone did not take part in the formation of the supratemporal fossa in *L. canadensis* (loc. cit. P. 226).

The orbits are shorter and broader than in *L. sternbergii.* This is due, in part at least, to the greater excavation of the frontals and the posterior development of the lachrymals.

The external nares are confluent. The aperture is heart-shaped and as in the Lance species is broader than long.

The anterior palatine vacuities are relatively large and egg-shaped with the posterior ends pointed. They extend back to the posterior extremity of the inner borders of the premaxillae.

The posterior palatine vacuities do not differ greatly from those of *L. sternbergii.* Only the anterior

border of the posterior nares is shown. This aperture appears to be similar to that of the Lance species.

BONES OF THE SKULL

The occiput and lower portion of the brain case are largely restored and nothing can be added to Lambe's description of this region and the quadrate.

The coalesced parietals are shorter than those of *L. sternbergii.* The suture between these bones and the frontals runs transversely just posterior to the anterior edge of the supratemporal fossa. From this point the suture runs downward, outward and very slightly forward to meet the postero-internal angle of the postfrontal.

The coalesced frontals somewhat resemble those of *Diplocynodon hautoniensis,* figured by Owen as *Crocodilus hastingsiae,*[5] but are more excavated by the inner borders of the orbits. The interorbital portion is narrower than in *L. sternbergii,* due also to the enlargement of the orbits. The anterior process of the frontals is long and quite slender. It runs forward to almost in line with the anterior ends of the prefrontals, divides the posterior tips of the nasals, and ends in a sharp point on the midline of the skull.

The prefrontal is moderately narrow and long. It forms about one third of the inner border of the orbit. The frontal-prefrontal suture commences a little behind the middle of the inner border of the orbit and runs slightly inward and forward in a broad curve and then forward, almost parallel to the midline, to near the anterior end of the frontal and then curves gently outward and forward as the posterior tip of the nasal is wedged in between it and the frontal. The prefrontal-lachrymal suture commences at the anterior part of the inner border of the orbit and continues forward to the nasal, parallel to the midline of the skull.

The lachrymal is broader than the prefrontal and the posterior end, which forms the anterior edge of the orbital

[5] Fossil Reptilia of the London Clay, etc., Palaeontographical Soc. 1850, Tab. VI.

rim, is strongly concave. Its internal border is almost parallel to the midline of the skull but the outer border runs slightly inward as the bone continues forward and ends in a sharp point between the nasal and the maxilla.

The jugal does not differ greatly from that of *L. sternbergii*. The extreme posterior tip is not preserved but the suture between it and the quadratojugal is well shown behind the anterior edge of the lateral temporal fossa.

The nasal which is long and pointed at both ends resembles that of *Crocodilus acer* Cope.[6] It is broadest in the posterior portion just in advance of where it is met by the antero-external tip of the prefrontal. From this point the postero-external edge of the bone runs sharply inward and backward and ends in a rather short but sharp point which is wedged in between the prefrontal and the anterior process of the frontal. From the widest point they gradually narrow as they continue forward and end in long slender points which are wedged in between the premaxillae. The bones, as preserved, do not quite reach the external nares but there is a space between the premaxillae and shallow grooves on the inner side of those bones and it is believed that in life the nasals reached the external nares.

The maxilla is broader than in *L. sternbergii*. It is very slightly convex superiorly but at the external edge of the skull, as in that species, it bends sharply downward and inward in its posterior portion and downward, at about right angles, in its anterior portion. This lateral surface of the maxilla, as well as a similar surface on the premaxilla, is marked by a series of rather large, deep, pits. There is a convex area above the fangs of the fourth and fifth teeth and over these same teeth the lateral border of the bone is much swollen outward. In advance of this swelling the maxilla narrows very rapidly to the anterior end of the bone, thus forming the posterior border of a deep, sharply defined notch for the reception of the lower canine teeth. Anteriorly the maxilla meets the premaxilla, behind the middle of the

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[6] Rep. of U. S. G. S. of Ter. Vol. III, Book I, Pl. XXIII, Fig. 1.

notch, at almost right angles to the midline of the skull. On the palatal surface the maxillae extend somewhat farther back than in *L. sternbergii* and the maxillo-premaxillary suture is much more concave. The antero-internal tips of the palatal portion of the maxillae are pointed and just reach the premaxillary aperture. This point is in line with the posterior edge of the last premaxillary tooth.

The p r e m a x i l l a e are broader than in *L. sternbergii.* From their union with the maxillae the external borders run forward for a short distance and then forward and outward to their broadest point. Internal to the transverse portion of the maxillo-premaxillary suture the prema-illa tapers backward in a long point which wedges in between the anterior end of the maxilla and the nasal. Between and posterior to the first and second premaxillary teeth is a pit for the reception of the first dentary tooth. Between and internal to teeth three and four is a shallower pit for the reception of the second dentary tooth.

The p a l a t i n e is broader and more constricted in the posterior half than in *L. sternbergii.* From about the midlength the anterior portion of the palatine flares outward into a broad anterior portion which is three times as broad as it is at midlength. It forms the whole of the internal border of the posterior palatine vacuity. The palatal plate of the maxilla sends a short, pointed process backward overlapping the palatine in the external half of its anterior portion. This process fits into a depression in the palatine. The anterior end of the palatine meets the maxilla opposite the pterygoids with an undulating transverse suture. This suture is well shown in Pl. XVI.

TEETH

The dental formula of *L. canadensis* is probably the same as in *L. strenbergii* but only the anterior fifteen maxillary alveoli are preserved. There are thirteen teeth preserved in the skull. These represent, on one side or the other, all of the premaxillary teeth and numbers 3, 4, 5, 6, 9, and 11 in the maxillae. The alveoli are all separated by distinct partitions

but that between the fourth and fifth maxillary teeth is very thin.

The teeth appear to be quite different from those from the Judith River formation, described and figured by Leidy as *Crocodilus humilus*.[7] When compared with the Judith River teeth those of the present specimen are proportionately shorter, broader transversely and lack folding on the crown. Loose teeth, in the collections of the Geological Survey of Canada, from the Belly River (Judith River) formation, show a decided folding of the crown and in general proportions compare very closely with Leidy's specimens.

The first and second premaxillary teeth are moderately long and slender and widely separated. In the second one the transverse diameter at the base is 6.5 mm. and the height of the crown is 13 mm. Numbers three and four are also widely separated and number four is the largest of the premaxillary teeth. The fifth and last is the smallest of this series. The distance between the premaxillary and the first maxillary teeth is 24 mm.

The alveolus for the first maxillary tooth about equalled the fifth premaxillary alveolus but is the smallest of the maxillary series as far as shown in the specimen. The second and third are progressively larger and the fourth and fifth, which are sub-equal, carry the largest teeth in the skull. In number five the crown has a transverse breadth of 12 mm. and a height of 20 mm. Numbers six, seven, eight, and nine are only a little larger than No. 1. The crown of No. 9 has a transverse breadth of 5 mm. and is 7 mm. high. Only the base of number eleven is preserved but it shows that this tooth was surpassed in size, in the maxillary series, by four and five only.

It is difficult to make accurate comparisons between the teeth of *L. canadensis* and *L. sternbergii* because those preserved in one specimen are, as a rule, not in the same position as those in the other but the teeth of the Belly River species appear to be relatively longer than in the Lance form. As

[7] Trans. Amer. Phil. Soc. Vol. XI, 1860, P. 146, Pr. XI, figs. 9-19.

in *L. sternbergii* the teeth are moderately pointed, in the smaller ones, to blunt, in the larger ones, but the cross section of the larger teeth is relatively broader transversely and there is no constriction between the crown and the fang.

Some of the mandibular teeth carry a very faint striation and the cross section of the base is relatively longer than in the maxillary teeth. There are alveoli for twenty-one teeth in the dentary as in *L. sternbergii.*

MEASUREMENTS OF THE SKULL, No. 8543.

Length of skull on midline	358 mm.
Length in front of orbits	225 mm.
Greatest breadth, outer angles, quadratojugals	195 mm.
Breadth of skull at anterior of orbits	158 mm.
Breadth across fifth maxillary tooth	112 mm.
Least breadth, at maxillo-premaxillary notch	60 mm.
Greatest breadth of premaxillae	81 mm.
Longitudinal diameter of orbit	58 mm.
Transverse diameter of orbit	58 mm.
Greatest longitudinal diameter of external nares	30 mm.
Transverse diameter of external nares	41 mm.
Longitudinal diameter of premaxillary vacuity	28 mm.
Transverse diameter of premaxillary vacuity	20 mm.
Length of posterior palatine vacuity	96 mm.
Length of frontals	120 mm.
Greatest breadth of frontals	50 mm.
Breadth of interorbital portion of frontals	19 mm.
Greatest length of prefrontals	76 mm.
Greatest breadth of prefrontals	21 mm.
Greatest length of lachrymals	80 mm.
Greatest breadth of lachrymals	29 mm.
Greatest length, superior portion, of maxilla	150 mm.
Greatest breadth, superior portion of maxilla	42 mm.
Greatest length of nasal	162+mm.
Greatest breadth of nasal	23 mm.
Length premaxillae, superior surface	99 mm.
Length premaxillae, palatal surface	63 mm.
From snout to anterior end of posterior palatine vacuity	180 mm.
Greatest length of palatines, midline	112 mm.
Greatest breadth of palatines, anterior	58 mm.
Least breadth of palatines	16 mm.

Geological Survey,
Ottawa, Canada.

PLATE XV.

Skull of *Leidyosuchus canadensis*, Lambe.

No. 8543 Geol. Surv., Can., Superior view, one-half natural size. E. na. external nares, F. frontal, L. lachrymal, L. t. f. lateral temporal fossa, M. maxilla, N. nasal, O. orbit, Oc. c. occipital condyle, P. parietal, Pf. postfrontal, Prf. prefrontal, Prm. premaxilla, Q. quadrate, Qj. quadratojugal, St. f. supratemporal, fossa, Sq. squamosal.

PLATE XV.

PLATE XVI.

Skull of *Leidyosuchus canadensis*, Lambe.

No. 8543 Geol. Surv., Can., inferior view one-half natural size. J. jugal, P. palatine, Po. n. posterior nares, P. p. v. posterior palatine vacuity, Pm. v. premaxillae vacuity, Pt. pterygoid, Tp. transpalatine.

PLATE XVI.

PENNSYLVANIAN OSTRACODA OF THE WAYLAND SHALE OF TEXAS

H. N. CORYELL AND GLADYS D. BILLINGS

The material yielding the micro-fauna included in the following discussion was collected by the senior author in 1930 from a locality 5 miles east and 2000 feet north of Cisco, Texas, along the highway leading from Cisco to Eastland. The microscopic forms include Bryozoa, Foraminifera and Ostracoda in considerable abundance. The Ostracodes are particularly well preserved. Several new species have been figured and described, which may be of use to future workers in making a study of the formation. The old species have been redescribed and figured to show the peculiar characteristics of the Wayland specimens when they are compared to those from other localities.

The Wayland shale is the uppermost member of the Graham formation of Cisco group in North Central Texas. Its position in the geologic column is shown on the accompanying chart.

SYSTEMATIC DESCRIPTIONS

Phylum ARTHROPODA

Class CRUSTACEA

Order OSTRACODA

Super Family CYPRIDACEA

Family BAIRDIIDAE Brady & Norman

Genus BAIRDIA Mc Coy, 1844

Bairdia McCoy, Syn. Carb. Limestone Foss. Ireland, 1844, p. 165, pl. 23.

Bairdia summa Coryell and Billings n. sp.

Plate XVII, Fig. 1.

Carapace with greatest height and thickness central; dorsal margin regularly and highly arched centrally; postero-

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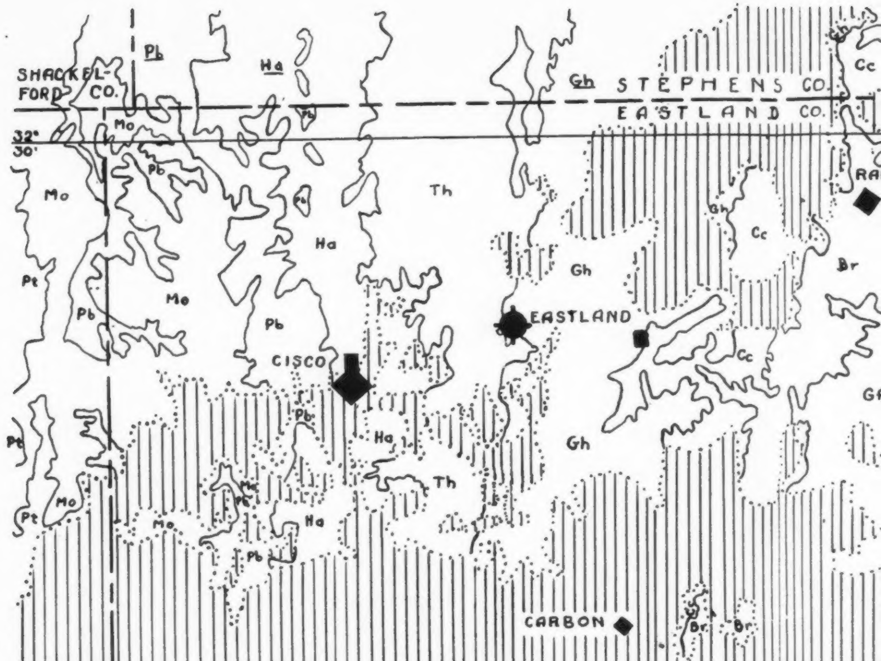
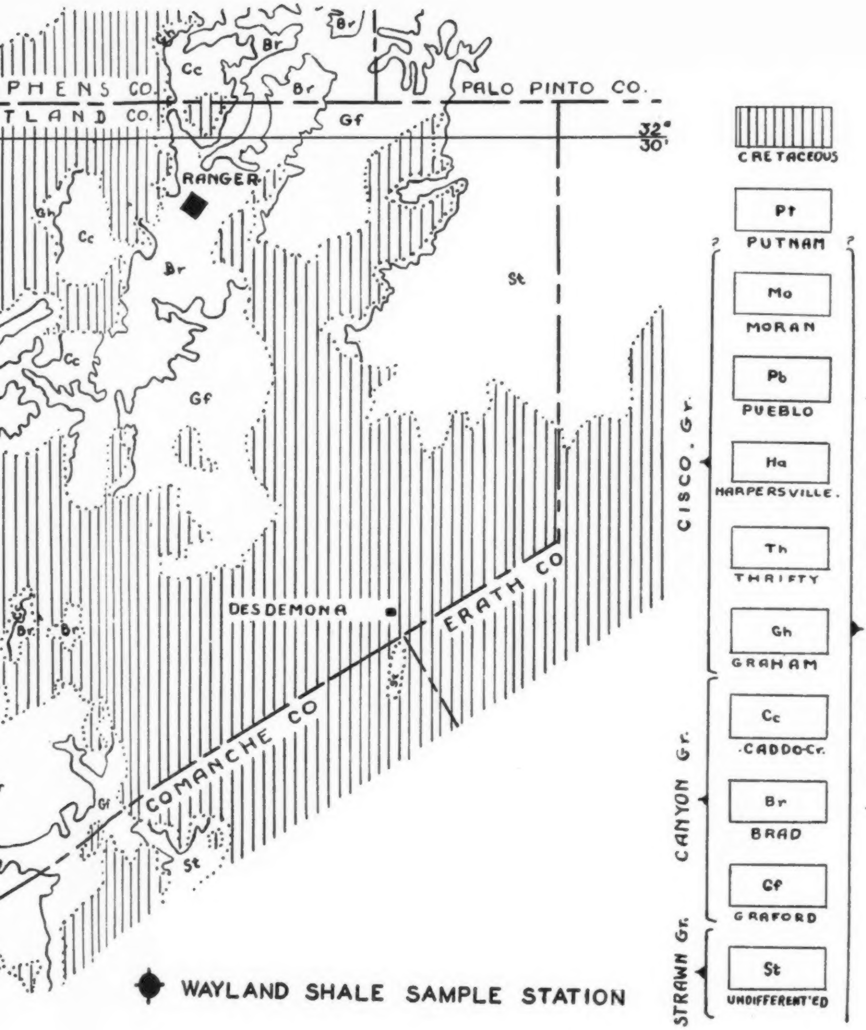


AREAL MAP OF EASTLAND COUNTY,



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PENNSYLVANIAN OF NORTH CENTRAL TEXAS

Permian			
Pennsylvanian	Cisco	Putnam fm.	Coleman Junction ls.
		Moran fm.	Sedgwick ls.
		Pueblo fm.	Camp Colorado ls.
		Harpersville fm.	Belknap ls.
			Crystal Falls ls.
		Thrifty fm.	Breckenridge ls.
			Avis ss.
		Graham fm.	WAYLAND SHALE
			Gunsight ls.
			South Bend sh.
			Bunger ls.
			Gonzales sh.
			Jacksboro ls.
			Finis sh.
	Canyon		
	Strawn		
	Bend		
Mississippian			

dorsal slope slightly concave near the low posterior beak; antero-dorsal slope nearly straight to the anterior end of the dorsal overlap; ventral margin gently rounded; ventral overlap central and only partially occupying the ventral depression in the right valve; inner margin of the ventral depression is marked by a fold paralleling the ventral overlap; contact of the left valve; surface of valves smooth.

Length, 1.20 mm.; Height, .66 mm.; Thickness, .45 mm.

Holotype, Columbia University Paleo. Coll. No. 25227.

Bairdia subvexa Coryell and Billings n. sp.

Plate XVII, Fig. 2.

Carapace elongate; greatest height near the center of the anterior half; greatest thickness near the center of the posterior half; anterior third of the dorsal border is curved regularly; posterior two-thirds of the dorsal margin is straight, dipping posteriorly; ventral border is concave near the center and curves broadly upward at each extremity; left valve overlaps the dorsal margin only along the anterior third; the overlap also occurs along the entire free margin except on the anterior edge; shell surface smooth.

Length, 1.15 mm.; Height, .57 mm.; Thickness, .45 mm.

Holotype, Columbia University Paleo. Coll. No. 25228.

Bairdia oklahomaensis Harlton 1927

Plate XVII, Fig. 3.

Bairdia oklahomaensis Harlton, Journ. Pal., vol. 1, 1927, no. 3, p. 209, pl. 33, fig. 7, (Upper Deese, Carter County, Oklahoma).

Bairdia oklahomaensis Harlton, Univ. of Texas Bull. 2901, p. 156, pl. 3, fig. 5.

Bairdia oklahomaensis Warthin, Okla. Geol. Surv. Bull. 53, 1930, p. 69, pl. 5, figs. 8a, b.

Carapace subrhombohedral in lateral view; greatest height and thickness anterior of center; postero-dorsal slope steep with a bend outward in the middle; antero-dorsal slope short, straight; posterior end acuminate; ventral border slightly concave; anterior end broadly rounded, truncated antero-ventrally; left valve overlaps right all around, over-

lap being strongest on dorsal and ventral margins; surface smooth.

Length, .83 mm.; Height, .50 mm.; Thickness, .40.

Bairdia acetalata Coryell and Billings n. sp.

Plate XVII, Fig. 5.

Bairdia subelongata Harlton (not Jones and Kirby), Univ. of Texas Bull. 2901, 1929, p. 157, pl. 3, fig. 6a. (Canyon, Menard County, Texas.)

Bairdia subelongata Harlton, Jour. Paleo. vol. 1, 1927, no. 3, p. 210, pl. 33, fig. 11.

Bairdia subelongata Knight, Jour. Paleo., vol. 2, 1928, no. 4, p. 326, pl. 43, fig. 9.

Carapace elongate, subovate in lateral view; greatest height and thickness central or slightly posterior of center; the line of greatest length intersects the line of greatest height approximately midway; the antero-dorsal margin straight to very broadly convex; anterior end evenly rounded; postero- dorsal slope straight or very broadly convex; posterior beak bluntly acuminate; ventral border slightly concave in median part; dorsal overlap extends from posterior beak to the anterior dorsal margin; ventral overlap conspicuous near center, and is less distinct or only slightly showing in lateral view elsewhere along that margin; surface of valves smooth.

Length, 1.14 mm.; Height, .50 mm.; Thickness, .30 mm.

Holotype, Columbia University Paleo, Coll. No. 25229.

Bairdia moore Knight 1928

Plate XVII, Fig. 4.

Bairdia moorei Knight, Jour. Pal., vol. 2, 1928, no. 4, p. 318, pl. 43, fig. 1, a, c.

Only right valves were found in this material.

Length, .74 mm.

Genus BYTHOCYPRIS Brady 1880

Bythocypris Brady, Rep. Voy. Challenger, Zool., vol. 1, 1880, p. 45, pl. 5, fig. 1.

Bythocypris centralis Coryell and Billings n. sp.
Plate XVII, Fig. 11.

Carapace small; greatest height and thickness central; dorsal margin broadly arched; posterior end nearly vertically truncate; anterior end slightly lower than posterior; ventral border slightly concave near the middle; anterior end regularly rounded; overlap narrow, entire in lateral view, slightly more conspicuous on ventral margin and posterior end; surface of valves smooth.

Length, .56 mm.; Height, .30 mm.; Thickness, .24 mm.

Holotype, Columbia University Paleo. Coll. No. 25230.

Bythocypris scapha Coryell and Billings n. sp.
Plate XVII, Fig. 10.

Carapace small and short with greatest height and convexity central; dorsal margin regularly arched; posterior end distinctly lower than the anterior; ventral margin medially nearly straight, with ends curving gently upward; anterior end broadly rounded; posterior end broadly rounded dorsally, but meeting the ventral border in a narrow almost angulated curve; left valve overlaps right all around; surface of valves smooth.

Length, .54 mm.; Height, .33 mm.; Thickness, .34 mm

Holotype, Columbia University Paleo. Coll. No. 25231.

Bythocypris procera Coryell and Billings n. sp.
Plate XVII, Fig. 12.

Carapace with greatest height anterior of the center; dorsal margin broadly arched, posterior end lower than the anterior; posterior and anterior ends are very broadly rounded; ventral margin nearly straight, bending upward to the anterior margin in a broad curve and meeting the posterior margin in a subangular curve; the left valve overlaps the right all around, a little more prominent on the anterior; curface of the valves smooth.

Length, 54 mm.; Height, .30 mm.; Thickness, .20 mm.

Holotype, Columbia University Paleo. Coll. No. 25232.

This species differs from *B. centralis* n. sp. in having the greatest height anterior of the middle and the posterior height more conspicuously less than the greatest height.

Bythocypris tomlinsoni Harlton 1929

Bythocypris tomlinsoni Harlton, Am. Jour. Sci., vol. XVIII, ser. 5, 1929, p. 270, pl. 2, fig. 17a-d. (Dornick Hills fm., Carter Co., Okla.)

Plate XVII, Fig. 9.

Carapace with greatest height and thickness slightly posterior of center; dorsal margin low arch, sloping down to the low, rounded anterior end; posterior end truncated vertically and postero-ventrally; ventral margin straight; left valve overlaps right all around, the overlap being greatest on the ventral margin; surface smooth.

Length, .39 mm.; Height, .22 mm.; Thickness, .15 mm.

Genus **Waylandella** Coryell and Billings n. gen.

Genotype, *Waylandella spinosa* Coryell and Billings n. sp.

Carapace small; left valve overlaps the right all around, the overlap being most conspicuous on the dorsal and ventral margins; dorsal margin convex, ventral margin less convex; two spines are present near the posterior margin of each valve and extend posteriorly.

Range and Occurrence.—Graham f m., Wayland shale, Eastland County, Texas.

This genus is similar to *Bythocypris* in the overlap of the valves; it is like *Healdia* in the presence of spines close to the posterior end. It differs from *Bythocypris* in the presence of the posterior spines, and from *Healdia* in the absence of the postero-dorsal slope.

Waylandella spinosa Coryell and Billings n. sp.

Plate XVII, Fig. 7.

Carapace with greatest height and thickness posterior of center; anterior height less than the posterior height; dorsal margin a low arch; posterior end truncated; ventral margin very broadly convex; anterior end broadly rounded; left

valve overlaps right all around, most conspicuous on ventral and dorsal margins; the two spines near the posterior end of each valve are short, blunt and separated from one another by a distance equal to about 3 times the diameter of the lower spine; surface smooth.

Length, .56 mm.; Height, .36 mm.; Thickness, .25 mm.

Holotype, Columbia University Paleo. Coll. No. 25233.

Waylandella fornicata Coryell and Billings n. sp.

Plate XVII, Fig. 6.

Carapace short, ovoid; greatest height approximately central; greatest thickness slightly behind the center; dorsal border highly arched, ventral border broadly convex; posterior end blunt; anterior end broadly rounded; the dorsal and ventral overlaps of left valve are of equal importance and greater than elsewhere; the two posterior spines are separated from one another by a distance equal to about 2 times the diameter of the lower spine; surface of valves smooth.

Length, .55 mm.; Height, .35 mm.; Thickness, .25 mm.

Holotype, Columbia University Paleo. Coll. No. 25234.

This species is especially characterized by its short ovoid outline and high, arched, dorsal margin.

Waylandella waylandica Coryell and Billings n. sp.

Plate XVII, Fig. 8.

Carapace sugrectangular; greatest height nearly central; greatest thickness slightly behind the center; dorsal border gently convex; posterior height greater than the anterior; ventral border straight; anterior end broadly rounded; the overlap of the left valve is greatest on the ventral border; the posterior two spines are short and separated from one another by a distance equal to about twice the diameter of the lower spine; surface smooth.

Length, .55 mm.; Height, .33 mm.; Thickness, .24 mm.

Holotype, Columbia University Paleo. Coll. No. 25235.

This species is distinguished from *W. spinosa* in the narrower overlap of the left valve, the closer spaced posterior

spines. The posterior height is more nearly equal to the greatest height, and the posterior margin is acutely truncated.

Genus HEALDIA Roundy 1926

Genus *Healdia Roundy*, 1926, Prof. Paper 146, p. 8.

Healdia cincta Coryell and Billings n. sp.

Plate XVII, Fig. 17.

Carapace small, short; greatest height anterior of the center; anterior end higher than the posterior; greatest thickness near the posterior end; dorsal margin angulated, curving gradually into the broadly rounded anterior; ventral border slightly convex, curving regularly into the anterior and posterior extremities; left valve overlaps the right, but inconspicuously on the postero-dorsal slope when observed in lateral view; the two spines near the posterior end joined by a definite ridge; surface of shells smooth.

Length, .47 mm.; Height, .25 mm.; Thickness, .20 mm.
Holotype, Columbia University Paleo. Coll. No. 25236.

Healdia quadrispinosa Coryell and Billings n. sp.

Plate XVIII, Fig. 12.

Carapace small, subrectangular; greatest height nearly central; posterior end only slightly lower than the anterior; greatest thickness very near the posterior end; dorsal margin broadly arched; posterior end abruptly truncated; ventral margin straight curving into the broadly rounded anterior end and meeting the posterior margin at an angle; left valve overlaps the right all around, except on the postero-dorsal slope as seen in lateral view; two prominent spines protrude posteriorly from near the dorsal and ventral ends of the posterior margin of each valve and extend beyond the edge of the shell; no posterior ridge present.

This species is distinguished by the low dorsal margin, the prominence and position of the spines and the rectangular shape of the shell.

Length, .45 mm.; Height, .25 mm.; Thickness, .20 mm.
Holotype, Columbia University Paleo. Coll. No. 25237.

Healdia cuneata Coryell and Billings n. sp.
Plate XVIII, Fig. 14.

Carapace small, subrectangular; greatest height central; greatest thickness at posterior end; dorsal margin gently convex; posterior end abruptly truncated; ventral border slightly concave, curving into the broadly rounded anterior end; a ridge extends along the posterior edge of the shell with one spine protruding from the dorsal end of the ridge on each valve; left valve overlaps the right all around, but not visible on the postero-dorsal slope as seen in lateral view.

Length, .39 mm.; Height, .24 mm.; Thickness, .17 mm.

Holotype, Columbia University Paleo. Coll. No. 25248.

Healdia alba Coryell and Billings n. sp.
Plate XVIII, Fig. 13.

Carapace small, ovate, short; greatest height nearly central; anterior height only slightly greater than the posterior height; dorsal margin arched, angulated; postero-dorsal slope flattened, posterior end rounded; anterior end broadly rounded; ventral margin convex, curving into the rounded anterior and posterior ends; left valve slightly overlaps the right all around except on the postero-dorsal slope; two conspicuous spines protrude from near the posterior end of each valve and extend beyond the posterior margin; surface of valves smooth.

Length, .40 mm.; Height, .25 mm.; Thickness, .18 mm.

Holotype, Columbia University Paleo. Coll. No. 25239.

Healdia compressa Coryell and Billings n. sp.
Plate XVIII, Fig. 15.

Carapace short; dorsal margin angulated; postero-dorsal slope low, concave; posterior end round; antero-dorsal slope short, very broadly arched; anterior end broadly rounded; ventral margin straight at center, curving into the rounded anterior and posterior ends; left valve overlaps the right all around, except on the postero-dorsal slope; two spines protrude from the posterior portion of each valve.

Length, .29 mm.; Height, .20 mm.; Thickness, .14 mm.

Holotype, Columbia University Paleo. Coll. No. 25240.

This species differs from *Healdia alba* n. sp. in its smaller size with spines placed farther anteriorly from the posterior margin, in the higher arch of the dorsal margin and distinct concavity of the posterior dorsal slope as it appears in lateral view.

Healdia absentia Coryell and Billings n. sp.

Plate XVII, Fig. 13.

Carapace small, broadly ovoid, valves regularly convex; greatest height at center; postero-dorsal slope nearly straight, meeting anterior and posterior extremities roundly; left valve overlaps the right except on the postero-dorsal slope; the dorsal posterior spine position is occupied by a ridge; the ventral spine is minute and scarcely larger than a prominent granule; surface of valves smooth.

Length, .55 mm.; Height, .33 mm.; Thickness, .25 mm.

Holotype, Columbia University Paleo. Coll. No. 25241.

Healdia miranda Coryell and Billings n. sp.

Plate XVII, Fig. 14.

Carapace small, short, subtriangulate; greatest height slightly posterior of the center; anterior height only slightly less than the maximum height; greatest thickness at posterior end; dorsal margin angulately arched; postero-dorsal slope shorter than the antero-dorsal, broadly arched margin; posterior margin broadly curved as observed in lateral view; anterior end narrowly rounded; ventral margin nearly straight; left valve overlaps the right all around, the overlap being slight on the postero-dorsal slope; a vertical ridge occurs near the posterior end of each valve; anterior of the ridge the convexity of the valves is regular, posterior of the ridge the surafce slopes steeply to the posterior margin.

Length, .59 mm.; Height, .25 mm.; Thickness, .20 mm.

Holotype, Columbia University Paleo. Coll. No. 25242.

Healdia simplex Roundy 1926

Healdia simplex Roundy, Prof. Paper 146, 1926, p. 8, pl. 1, fig. 11 a, c.

Plate XVII, Fig. 15.

Carapace small, short; the convexity of the valves regular and great; dorsal margin highly arched, curving down to the rounded anterior end, and sloping nearly straight to the posterior end; anterior and posterior ends of nearly equal height and much lower than the maximum height; ventral margin only slightly convex; postero-dorsal slope in dorsal view appears much flattened; left valve overlaps right except on postero-dorsal slope; surface of valves smooth.

Length, .60 mm.; Height, 38 mm.; Thickness, .30 mm.

Genus SEMINOLITES Coryell 1928

Seminolites Coryell, Journ. Pal., vol. 2, 1928, no. 2, p. 88.

Seminolites compressus Coryell 1928

Seminolites compressus Coryell, Journ. Pal., vol. 2, 1928, no. 2, p. 89, pl. 11, fig. 3.

Plate XVIII, Fig. 1.

Carapace elongate; greatest height is in front of the center; anterior extremity is more broadly rounded than the posterior; ventral margin nearly straight, with its extremities meeting the anterior and posterior margins roundly; posterior ridge prominent and close to the margin of the valve; anterior ridge is a shallow depression, broadly curved equal to approximately one-sixth of the length; left valve overlaps the right all around, the overlap being most conspicuous on the ventral margins; a few pits occur on the central convex surface and in the curved depressions.

Length, .69 mm.; Height, .46 mm.; Thickness, .31 mm.

Seminolites truncatus Coryell 1928

Seminolites truncatus Coryell, Journ. Pal., vol. 2, 1928, no. 2, p. 88, pl. 11, fig. 1.

Plate XVIII, Fig. 3.

Carapace subtriangular with the apex of the dorsal arch slightly in front of the center; anterior end broadly rounded; posterior end lower than the anterior; ventral margin is broadly convex; surface is ornamented with a prominent terminal ridge on the posterior end, and a shallow depression on the anterior end; surface is marked with irregularly distributed pits.

Length, .69 mm.; Height, .43 mm.; Thickness, .31 mm.

Seminolites elongatus Coryell 1928

Seminolites elongatus Coryell, Journ. Pal., vol. 2, 1928, no. 2, p. 88, pl. 11, fig. 2.

Plate XVIII, Fig. 2.

Carapace lower and narrower than *S. truncatus* and the highest part of the dorsal arch is farther toward the anterior; posterior end much lower than the anterior; posterior terminal ridge is conspicuous, with a corresponding depression and ridge on the anterior end; surface with few irregularly distributed pits.

Length, .64 mm.; Height, .36 mm.; Thickness, .27 mm.

Family CYTHERELLIDAE Sars 1865

Genus CAVELLINA Coryell 1928

Cavellina Coryell, Journ. Pal., vol. 2, 1928, no. 2, p. 89.

Cavellina pulchella Coryell 1928

Cavellina pulchella Coryell, Journ. Pal., vol. 2, 1928, no. 2, pl. 11, fig. 5.
Cavellina pulchella Warthin, Okla. Geol. Surv. Bull. 53, 1930, p. 78, pl. 7, fig. 3 a, b.

Plate XVII, Fig. 16.

Dorsal margin arched; greatest height near center; posterior end narrowly rounded; anterior end broadly rounded; ventral border convex, meeting anterior and posterior ends roundly; right valve larger, overlapping left valve all around, the overlap being most conspicuous on the dorsal and ventral margins.

Length, 1.0 mm.; Height, .62 mm.; Thickness, .40 mm.

Super Family BEYRICHIACEA

Family KIRKBYIDAE Ulrich and Bassler 1906

Genus KIRKBYA Jones 1859

Kirkbya Jones, Jones and Kirkby, 1859, Trans. Tyneside Nat. Field Club, vol. IV, p. 129.

Kirkbya clarocarinata Knight 1928

Plate XVIII, Fig. 11.

Kirkbya clarocarinata Knight, Journ. Pal., vol. 2, 1928, no. 3, p. 258, pl. 32, fig. 2; pl. 33, fig. 2.
Kirkbya clarocarinata Harlton, Univ. of Texas Bull. 2901, p. 152, pl. 2, fig. 3.

Carapace elongate; hinge line straight; ventral border broadly convex; meeting anterior and posterior ends roundly;

edges of shell bordered by a marginal rim, followed by a short inner flange, both visible from side view; a conspicuous swelling in the convexity of the valve is present on the central and dorsal portion of the anterior and posterior halves of the valve; the Kirkbyan pit situated below the middle of each valve; surface reticulate.

Length, .95 mm.; Height, .46 mm.; Thickness, .29 mm.

Moorites Coryell and Billings n. gen.

Genotype, *Moorites hewetti* Coryell and Billings n. sp.

Carapace subquadrate; valves apparently equal; dorsal border straight; the ends of the valve are bordered by a distinct raised flange which extends on to the extremities of the ventral margin; below the center of each valve the marginal rim becomes indistinctly marked or disappears in the regular convexity of the valve; the surface is pitted, the pits commonly occurring in elongate and curved depressions.

This genus differs from *Moorea* Jones and Kirkby in the shape of the test and ornamentation of the valves.

This genus is named for Dr. Raymond C. Moore of the University of Kansas.

Range and Occurrence. — Graham fm., Wayland Shale, Eastland County, Texas.

Moorites hewetti Coryell and Billings n. sp.

Plate XVIII, Fig. 5.

Carapace small, subquadrate, apparently equivalved; greatest height at posterior cardinal extremity; greatest thickness anterior to center; dorsal margin straight, cardinal angles sharp; height of the posterior end greater than that of the anterior; posterior margin rounded; ventral border straight, sloping upward anteriorly to the anterior margin; free margins bordered by an inflated marginal rim except in the mid-ventral region; valves ornamented by a low curved ridge separating the elongate depressed punctate areas.

Length, .48 mm.; Height, .21 mm.; Thickness, .13 mm.

Holotype, Columbia University Paleo. Coll. No. 25243.

This species differs from *Moorites minutus* (Warthin) in the anterior convergence of the ventral and dorsal margins.

Moorites minutus (Warthin) 1930

Glyptopleurina? minuta Warthin, Okla. Geol. Surv. Bull. 53, no. 4, 1930, p. 67, pl. V, fig. 6.

Plate XVIII, Fig. 6.

Carapace small, subquadrate; greatest height in posterior half; greatest thickness central; dorsal margin straight, cardinal angles sharp; valves appearing equal; ventral border slightly concave in front of the center, merging evenly with the anterior and posterior extremities; free margins bordered by an inflated marginal rim which is less distinct along the mid-ventral portion; valves ornamented with low ridges separating the elongate depressed punctated areas.

Length, .45 mm.; Height, .23 mm.; Thickness, 15 mm.

Moorites truncatus Coryell and Billings n. sp.

Plate XVIII, Fig. 7.

Carapace small, subquadrate; valves appearing equal; greatest height near the posterior end; greatest thickness near the anterior end; dorsal margin straight; posterior end narrowly rounded; anterior end vertically truncated; ventral margin is concave near the center; free margin bordered by an inflated marginal rim except along the mid-ventral portion; valves ornamented by indistinct longitudinal low ridges that separate the elongate, slightly depressed, punctate areas.

Length, .37 mm.; Height, .22 mm.; Thickness, .11 mm.

Holotype, Columbia University Paleo. Coll. 25244.

This species differs from *Moorites hewetti* n. sp. in the shorter and higher carapace and indistinct ornamentation.

Genus AMPHISSITES Girty 1910

Amphissites Girty, Ann. N. Y. Acad. Sci., vol. 20, 1910, p. 235.

Amphissites simplissimus Knight 1928

Amphissites simplissimus Knight, Journ. Paleo., vol. 2, 1928, no. 3, p. 266, pl. 32, figs. 11 a, d; pl. 34, fig. 6.

Amphissites simplissimus Harlton, Univ. Texas Bull., 2901, 1929, p. 151, pl. 1, figs. 13 a, d.

Amphissites simplissimus Warthin, Okla. Geol. Surv. Bull. 53, 1930, p. 67, pl. 5, figs. 1 a, b.

Plate XVIII, Fig. 10.

Carapace small, apparently equivalved; dorsal margin straight; posterior cardinal extremity rounded, the anterior slightly angulated; ventral margin broadly convex, curving into the rounded anterior and posterior ends; a Kirkbyan pit is developed near the middle of each valve; surface reticulate with spines developed at some of the angles of reticulation.

Lngth, .73 mm.; Height, .45 mm.; Thickness, .23 mm.

Amphissitcs centronotus (Ulrich & Bassler) 1906

Kirkbya centronota Ulrich & Bassler, Proc. U. S. Nat. Mus., vol. 30, 1906, p. 159, pl. 11, figs. 16-17. (Cottonwood shale, Chase County, Kansas.)

Amphissites centronota Harlton, Journ. Pal., vol. 1, 1927, no. 3, p. 207, pl. 32, fig. 10 a, b.

Amphissites centronotus Warthin, Okla. Geol. Surv. Bull. 53, 1930, p. 66, pl. 5, fig. 4 a, c.

Amphissites centronotus Delo, Journ. Pal., vol. 4, 1930, no. 2, p. 160, pl. 12, fig. 9.

Plate XVIII, Fig. 9.

Carapace small; greatest height and thickness central; hinge line straight, depressed; cardinal angles sharp; nearly a right angle; ventral border broadly convex, curving into the rounded anterior and posterior ends; a marginal ridge parallels the free border of the valves, and a second one occurs parallel to the first and separated from it by three or four rows of reticulation pits; it is this latter one that is the conspicuous marginal ornamentation as seen in the figures of a lateral view; a node occurs in the middle of each valve, bordered on each side by an anterior and posterior ridge, which extends from the dorsal margin to slightly beyond the middle of the valve; surface reticulated.

Length, .81 mm.; Height, .50 mm.; Thickness, .32 mm.

Amphissites dattonensis Harlton 1927

Plate XVIII, Fig. 8.

Amphissites dattonensis Harlton, Journ. Pal., vol. 1, no. 3, 1927, p. 206, pl. 32, figs. 9 a, b.

Amphissites dattonensis Harlton, Univ. of Texas Bull. 2901, 1929, p. 149, pl. 1, fig. 9 a, b.

Amphissites dattonensis Warthin, Okla. Geol. Surv. Bull. 53, 1930, p. 64, pl. IV, fig. 15.

Carapace small; valves equal; greatest height at posterior end; greatest thickness central; dorsal margin straight and shorter than the ventral margin; cardinal angles obtuse; each valve ornamented with a prominent dorso-ventrally elongated node near the middle of the valve; curved pronounced ridge on dorso-anterior end of valve extends ventrally from the anterior cardinal extremity to a little beyond the median height; another ridge parallels the mid-ventral border and does not distinctly unite with the anterior ridge; the middle of the postreior half is marked by a vertical swelling; surface of valves reticulated.

Lenght, .68 mm.; Height, .39 mm.; Thickness, .33 mm.

Family BEYRICHIIDAE Jones

Genus HOLLINELLA Coryell, 1928

Hollinella Coryell, Journ. Pal., vol. 2, 1928, no. 4, p. 378.

Hollinella bassleri (Knight) 1928

Plate XVIII, Fig. 4.

Hollina bassleri Knight, Journ. Pal., vol. 2, 1928, no. 3, pl. 31, fig. 3; pl. 34, fig. 7. (Upper Ft. Scott limestone, St. Louis County, Missouri.)

Hollinella bassleri Kellett, Journ. Pal., vol. 3, 1929, no. 2, pl. 25, fig. 5 a, c. (Upper Ft. Scott limestone, St. Louis County, Missouri.)

Dorsal margin straight; cardinal angles obtuse; greatest height nearly central; ventral margin slopes upward anteriorly to the rounded anterior border; ventral and postero-ventral margins of shell bordered by a narrow frill (broken in places) ; a large elongate node is present on each valve anterior of the median sinus; a smaller, less prominent node posterior of the sinus; surface finely granulose.

Length, 1.10 mm.; Height, .67 mm.

Only a left valve was found in this material.

PLATE XVII.

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PLATE XVII.

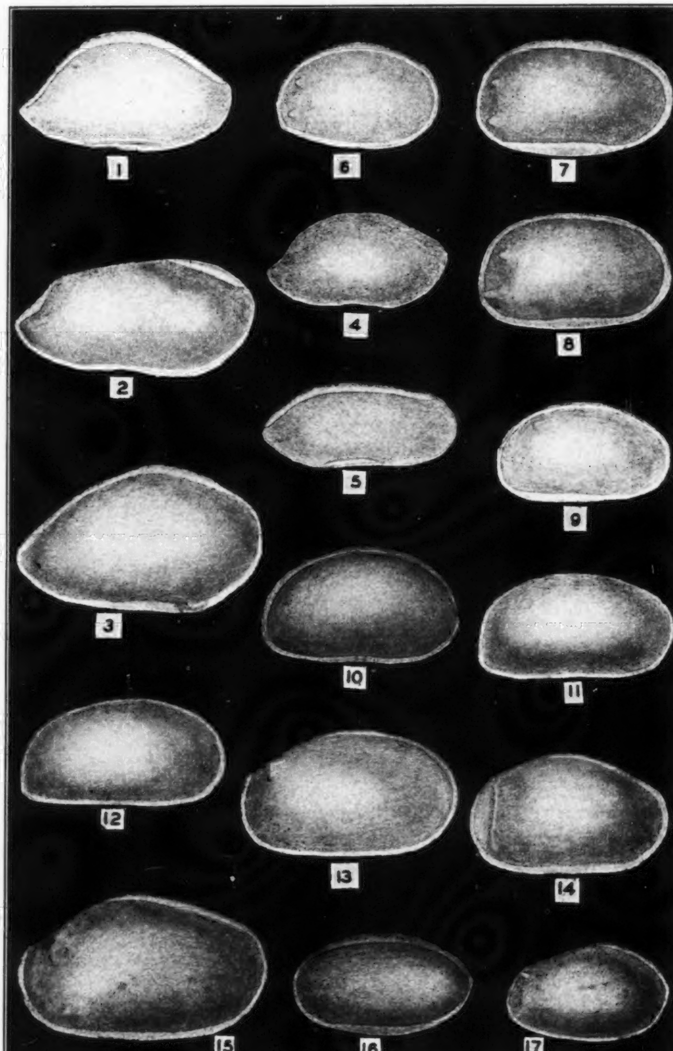

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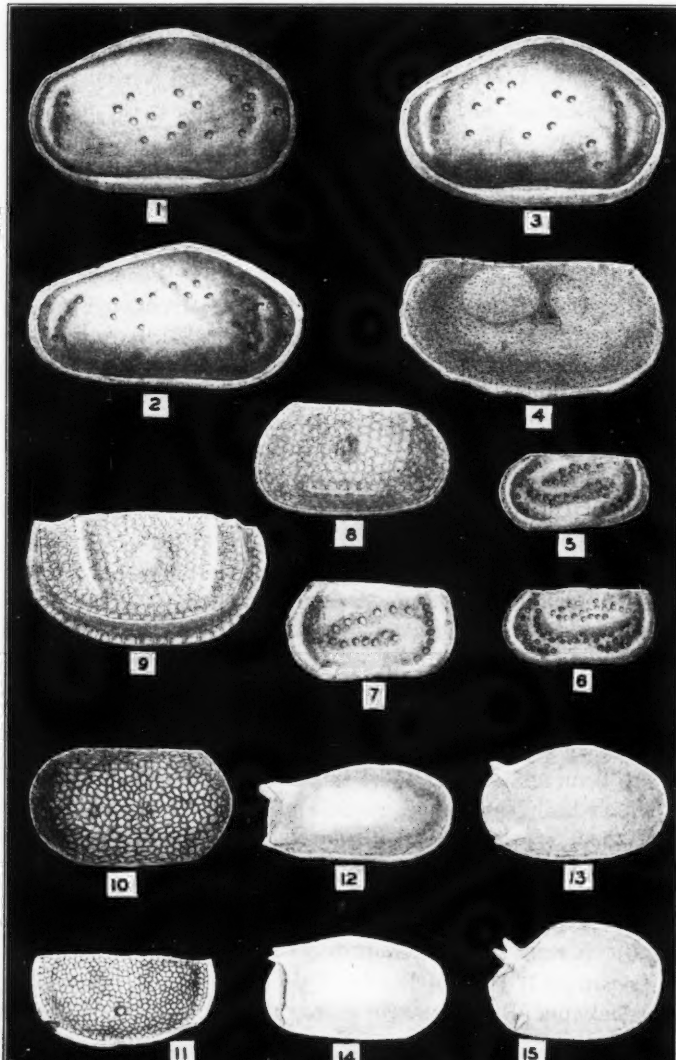
Plate XVIII.



SIGNIFICANT FORAMINIFERA FROM THE RIPLEY FORMATION OF ALABAMA

JOHN R. SANDIDGE

A study of foraminifera from the Cretaceous sediments of Alabama undertaken for the Alabama Geological Survey has revealed certain species from the Ripley formation that merit special consideration. They include several established species that appear to be somewhat confused in recent American literature and three new species that occur frequently in the Ripley formation. These forms may be useful to workers in nearby areas for purposes of correlation and for establishing faunal relationships. They are particularly likely to appear in cuttings from deep wells located in the eastern part of the Gulf Embayment.

The writer is indebted to the Geology Department of Princeton University for financial assistance in the preparation of the illustrations.

Holotypes of the new species, and plesiotypes of other species, will remain in the possession of the author. Topotypes will be deposited in the Alabama Museum of Natural History and at Princeton University.

The localities from which the described species were obtained are as follows:

Locality 53, Barton's Bluff.—About 8 miles above Moscow on the Tombigbee River there is an exposure of about 60 feet, in which both the Selma chalk and Ripley occur. This is a fault zone, where vertical displacement has brought the two facies into juxtaposition. The Ripley at this point is highly calcareous but presents the usual sandy, glauconitic aspect, and is very similar to the exposure at Boguechitto Creek. It contains a very rich formaniniferal fauna.

Locality 87, Prairie Bluff.—This upper Ripley locality on the Alabama River, made classic by the early work of

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Toumey,[1] Winchell,[2] and Smith,[3] is about 6 miles southeast of the town of Catherine, Wilcox County, and may be reached by a local road from this village to the old Prairie post office. The exposure forms a bluff about 100 feet high where the strata dip at the unusual rate of 300 feet to the mile. At the top there is a blue limestone containing *Exogyra costata*, (Say), *Gryphea vesicularis* Lamarck, and large numbers of phosphatized shell casts. It has a thickness of 8 to 10 feet. Below this stratum there occurs a sandy chalk deposit approximately 20 feet thick. The lower part of this bed, near the middle of the bluff, is marked by a hard ledge made up largely of shells. The remainder of the exposure, extending to water level, consists of beds of loose, richly glauconitic, slightly argillaceous sands alternating with indurated ledges of the same materials, apparently cemented by calcareous deposits. Megafossils occur frequently but are not abundant. The foraminifera found at this locality are uniformly small, and few species are represented. The fauna occurring in the sandy beds is especially impoverished.

Locality 105, Red Bluff.—Just north of the boundary between Wilcox and Dallas counties on the Alabama River there is a remarkably high bluff in the lower part of which 40 to 50 feet of Ripley are exposed. This deposit is massively bedded and consists of alternating layers of dark-blue micaceous clay, and clay containing varying amounts of fine sand. The clay is predominant. Large fossils are present, but not abundant. A rich microfauna has been found. The horizon appears to be low in the Ripley of this region.

Locality 106, Boguechitto Creek.—A low bluff occurs at the point where Boguechitto Creek joins the Alabama River, and a fault brings the Selma chalk up against the lower Ripley beds. The displacement appears to be about 25 feet. The Ripley strata are typical calcareous ledges, and contain numerous megafossils. The microfauna from this strati-

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[1] Toumey, M., First Bien. Rep. Geol. Surv. of Ala., 1850.

[2] Winchell, A., Proc. Amer. Assoc. Adv. Sci., vol. 10, 1856, p. 90.

[3] Smith, Eugene A., "Geology of the Coastal Plain of Alabama", Ala. Geol. Surv. Rep., 1894; U. S. Geol. Surv., Bull. 43, p. 189.

graphic position is exceedingly rich and well developed. The upper part of the chalk exposed at this locality contains *Exogyra costata* (Say) and *E. ponderosa* Roemer. It has a great many foraminifera, but the fauna does not appear to be as rich as that of the immediately overlying Ripley beds.

Family VERNEUILINIDAE

Genus CLAVULINA d'Orbigny

Clavulina insignis Plummer

Plate XIX, Figs. 1-4

Clavulina insignis Plummer, Univ. of Texas, Bull. 3101, p. 138, pl. 8, figs. 1-4, Oct. 1931.

Clavulina trilatera Cushman, Jour. Pal., vol. 5, p. 302, pl. 34, figs. 10, 11, Dec. 1931; Tenn. Geol. Surv., Bull. 41, p. 22, pl. 2, figs. 1-3, Jan. 1932.

Description. — Test elongate, triangular in horizontal section, tapering from a slightly rounded apertural end to a pointed apical end, angles sharply carinate to rounded; chambers numerous, triserial in early stages, later becoming uniserial, low, and arched; sutures indistinct in early portion; impressed between later chambers; wall finely arenaceous, usually smoothly finished; aperture generally trifurcate in shape, central and terminal on face of last chamber.

Remarks. — This species furnishes a splendid example of dimorphism in foraminifera, with microspheric and megalospheric forms, as described by Chapman,[1] present in the Ripley in large numbers. The microspheric form is characterized by its accentuated tripyramidal shape, sharp angles, concave sides, pointed apical end, broad and distinctly arched apertural face, and large size, and the more rapid broadening of the chambers with growth, which makes the test more flaring in lateral view. The proloculum is very small in this form, and the early triserial arrangement among the Ripley specimens usually does not extend beyond the first four or five chambers, although in the original type the number is greater. The remaining 10-12 chambers are uniserial, and

[1] F. Chapman, Journ. Linn. Soc. London, Zool., vol. 30, No. 195, p. 29, pl. 4, figs. 68-73, 1907.

so far as can be observed there is no intervening biserial arrangement. The aperture is centrally located on the broad and slightly arched face of the last chamber. It is trifurcate with a branch extending in the direction of each angle of the test. A delicate tooth is sometimes, but not always, present. The length of the microscopic form found in the Ripley averages 1.5 mm. The typical megalospheric form is elongate with sides nearly parallel, the apical end bluntly pointed, the apertural chamber somewhat rounded, the angles carinate, the walls only slightly concave, the sutures for the most part distinct and arched. The aperture is trifurcate, but the branches are short and lobed. A tooth may be present. The average length of this form is 1.2 mm.

This abundant and striking species is related to the one reported by Mrs. Plummer,[5] from the Midway of Texas, but, as this author has pointed out, the smoother finish and sharper angles make differentiation easy. It differs from *C. trilatera* as originally described by Cushman,[6] in having a smoother test, with unmistakably sharper angles, and in having a trifurcate aperture. Cognizance of these distinctions is implied in a recent synonomy and treatment of *C. trilatera* from the Cretaceous of Trinidad.[7]

O c c u r r e n c e . — *C. insignis* was described originally from the Navarro formation of Texas. In the Ripley it occurs

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[5] Plummer, Helen Jeanne, Univ. Tex. Bull. 2644, p. 70, pl. III, figs. 4, 5, 1926.

Note: Although originally assigned to *C. angularis* d'Orbigny by Mrs. Plummer, the Midway species now is regarded as distinct from that form, which is based on a living *Clavulina*, and should receive a new name. That *C. insignis* differs very definitely from *C. trilatera* Cushman also is firmly held by Mrs. Plummer, whose studies of these forms are based on material from the published localities at which they have been reported. — Personal communications from Helen Jeanne Plummer, Aug. 20, and Dec. 22, 1931.

[6] Cushman, J. A., Bull. Am. Asso. Petrol. Geol., vol. 10, p. 588, pl. 17, fig. 2, 1926.

[7] Cushman and Jarvis, U. S. Nat. Mus., Proc., vol. 80, Art. 14, p. 18, pl. 5, fig. 5, 1932.

throughout those portions of the formation which carry a typical fauna.

Family LAGENIDAE

Genus MARGINULINA d'Orbigny

Marginulina elongata d'Orbigny

Plate XIX, Fig. 15

Marginulina elongata d'Orbigny, Mém. Soc. géol. France, ser. 1, vol. 4, p. 17, pl. 1, figs. 20-22, 1840. — Franke, Abhn. preuss. geol. Landes., vol. 3, p. 76, pl. 7, fig. 5, 1928. — Cushman and Church, Proc. Calif. Acad. Sci., ser. 4, vol. 18, p. 506, pl. 38, figs. 1-3, 1929. — Cushman, Tenn. Geol. Surv., Bull. 41, p. 26, pl. 2, figs. 10a, b, Jan. 1931.

Description. — Test elongate, subcylindrical, slightly compressed in early stages, later stages inflated; early chambers closely coiled, later uncoiled and nearly globular in shape; sutures distinct, depressed in rectilinear part of test, oblique, sloping away from the periphery; wall calcareous, smooth; aperture eccentric, at the peripheral angle, radiate, protruding. Length of illustrated specimen, 0.75 mm.

Remarks. — Cushman's Recent form, *Marginulina bacheii*, which occurs abundantly along the Atlantic coast and in the Gulf of Mexico, closely approaches this species. The chief difference is in the shorter, stouter build of *M. elongata*, and in the smaller number of chambers making up its test. In all normal specimens examined, there are only four chambers in the uncoiled part of the shell, and four or five in the visible coiled portion.

Occurrence. — The species is fairly abundant in the Ripley beds exposed at the mouth of Boguechitto Creek, on Alabama River. The illustrated specimen was obtained at this locality (Locality No. 106).

Genus FLABELLINA d'Orbigny

Flabellina interpunctata von der Marck

Plate XIX, Figs. 12-14

Flabellina interpunctata von der Marck, Verh. nat. Ver. preuss. Rheinl., vol. 15, p. 53, pl. 1, fig. 5, 1858. — Reuss, Sitz. Akad. Wiss. Wien, vol. 40, p. 216, pl. 9, fig. 1, 1860. — White, Journ. Pal., vol. 2, p. 204, pl. 29, fig. 1, 1928. — Cushman, Contr. Cush. Lab. Foram. Res., vol. 6,

pt. 2, p. 30, pl. 4, figs. 16, 17, 1930; Jour. Pal., vol. 5, p. 307, pl. 35, fig. 9, Dec. 1931. — Plummer, Univ. of Texas, Bull. 3101, p. 163, pl. 12, figs. 1-3, Oct. 1931.

Description. — Test flat, compressed, generally rhomboid in outline, periphery truncate; chambers coiled in early stages, later ones extending down on either side in the plane of coiling; sutures raised, sharp, often with looplike structures at the tops of the chambers; wall between the sutures ornamented with numerous small papillae; aperture at the end of a short projection on the last chamber. Length of illustrated adult specimen, 1.6 mm.; juvenile forms, 0.45 mm.

Remarks. — An interesting association of juvenile representatives of this characteristic Cretaceous species occurs in material from the Ripley exposure at the mouth of Boguechitto Creek, on the Alabama River. Numerous specimens are present which show the early coiled stage of development, and the gradual elongation of succeeding chambers until they attain a form typical of *Vaginulina*. Intermediate stages between the *Vaginulina* form and the adult *Flabellina* in which the chambers begin to extend downward on both sides of the early coiled portion of the test have been found. This occurrence of juvenile and adult forms of *Flabellina interpunctata* in close association furnishes an excellent illustration of recapitulation among the foraminifera.

Occurrence. — Both juvenile and adult forms occur frequently at the horizon of the Ripley exposed on Boguechitto Creek where it enters the Alabama River (Locality No. 106).

Family HETEROHELICIDAE

Genus VENTILABRELLA Cushman

Ventilabrella plummerae n. sp.

Plate XIX, Figs. 5, 6

Description. — Test elongate, sides nearly parallel in later portion, earlier part tapering abruptly to a sharply pointed initial end, transverse section almost square in outline; chambers in early stages very small and planispirally

coiled, later biserial, increasing rapidly in size, last 3 to 4 pairs inflated, gradually becoming higher as added, oval to round in shape; sutures distinct, deeply impressed between later chambers; wall thin, surface marked by fine longitudinal striations; aperture a narrow, elongate arched slit following the contour of the inner margin of the last-formed chamber. Length of the holotype, 0.5 mm.

R e m a r k s . — This species corresponds identically to a form figured by Mrs. Plummer[8] from the Navarro formation of Texas, and indicated as *Pseudotextularia "d."* Its chief differences from *V. carseyae* Plummer are the more globular shape of the chambers, their more gradual increase in size in the later stages, and the lack of a median final chamber. The form approaches in its general characteristics Egger's *Guembelina striata.*[9]

O c c u r r e n c e . — *V. plummerae* occurs rarely in the lower part of the Ripley in central Alabama. The holotype is from the exposure at the mouth of Boguechitto Creek (Locality No. 106).

Genus BOLIVINOIDES Cushman

Bolivinoides decorata (Jones)

Plate XIX, Fig. 16

Bolivina decorata Jones, Proc. Belfast Nat. Field Club, Appendix, pl. 27, figs. 7, 8, 1885-86. — Plummer, Univ. of Texas, Bull. 3101, p. 181, pl. 10, fig. 10, 1931.

Bolivina latticea Carsey, Univ. of Texas, Bull. 2612, p. 27, pl. 4, fig. 9, 1926.

Bolivinoides decorata Cushman, Cont. Cush. Lab. Foram. Res., vol. 2, pt. 4, p. 89, pl. 12, fig. 9, 1927.

D e s c r i p t i o n . — Test elongate, heart-shaped, thickest and widest near the apertural end, tapering to the initial end, slightly compressed, edges rounded and smooth; sutures concealed by intersecting rows of short broken ridges running

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[8] Plummer, Helen Jeanne, Univ. Tex., Bull. 2644, pl. 2, fig. 4, 1926.

[9] Egger, Abh. bay. Akad. Wiss., München, Cl. II, vol. 21, Bd. I, p. 33, pl. 14, figs. 5, 6, 7, 10, 11, 37, 38, 39, 1899.

diagonally across the faces of the test; aperture at the inner edge of the last formed chamber. Length of illustrated specimen, 0.45 mm.

Occurrence. — This species occurs in the European Cretaceous and has been reported from the Taylor marl and Annona chalk of the Texas Cretaceous. It occurs rarely in the Ripley of Alabama.

Genus PSEUDOUVIGERINA Cushman

Pseudouvigerina (?) *plummerae* Cushman

Plate XIX, Figs. 9-11

Pseudouvigerina plummerae Cushman, Contr. Cushman Lab. Foram. Res., vol. 3, p. 115, pl. 23, figs. 8a, b, 1927; Tenn. Geol. Survey, Bull. 41, p. 46, pl. 7, figs. 15a, b, Jan., 1932.

Description. — Test elongate, trifacial, tapering gradually from a somewhat rounded apertural end to a pointed initial end, twisted, angles in early stages slightly carinate, later marked by double carinae; chambers in early stages triserial, compressed on two sides, becoming slightly inflated and rounded at the apertural end; sutures at first visible as dark lines of celar shell material, covered with very fine spines, a double row along the angles making them appear carinate; wall calcareous, thin; aperture terminal, central, oval-shaped, with a narrow lip or collar. Length of the ilustrated specimen, 0.28 mm.

Remarks. — This species, which is similar in many respects to *Angulogerina angulosa* (Williamson), possesses an aperture resembling that of *Uvigerinella*. It is distinctly elongate, and has a typical thin lip with a small notch at the inner end of the ellipse. There is no plate or tooth, nor an internal tube. No evidence of a planispiral or a biserial stage is evident in any of the specimens examined, either when viewed in sections or in transparent media. The characteristics show a combination of uvigerine, bulimine, and angulogerine features suggesting an intermediate form. The form may prove to be a link in the evolutionary series connecting *Bulimina* and *Trifarina*, probably falling between *Uvigerinella* and *Angulogerina*.

Occurrence. — The species is found frequently in the middle part of the formation in the Alabama River section. The illustrated specimen is from the exposure at the mouth of Boguechitto Creek (Locality No. 106).

Family BULIMINIDAE

Genus TURRILINA Andreae

Turrilina angulata n. sp.

Plate XIX, Figs. 7, 8

Description. — Test pyramidal, triserial, roughly triangular in cross-section, short, sides flattened, corners rounded, initial end slightly rounded, apertural end inflated; chambers in early stages small, compact, increasing in size as added, last few inflated, 5 to 7 in each series; sutures distinct, somewhat impressed between last chambers; wall calcareous, smoothly finished; aperture a small semicircular opening at the base of the apertural face. Length of the holotype, 0.3 mm.

Remarks. — This very small species is similar in its general characteristics to *Turrilina alsatica* Andreae, but differs from Andreae's representative in having its chambers flattened across the vertical sutures and pinched to form angles at the intersections of the flat faces. The new species resembles *Turrilina trochoides* (Reuss) as figured by Galloway and Morrey,[10] but it differs definitely from Ruess' [11] original figures of the species, and those of White,[12] which show a form with much inflated chambers, especially in the later stages, and no indications of flattened faces. Excellent preservation of the tests in the Ripley makes the form easy to recognize wherever it is encountered.

Occurrence. — The holotype is from Red Bluff (Locality No. 105).

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[10] Galloway, J. J., and Morrey, Margaret, Jour. Pal., vol. 5, p. 350, pl. 40, figs. 5a, b, 1931.

[11] Reuss, Verstein. Böhm. Kreide, p. 36, pl. 12, fig. 22, 1845-46.

[12] White, M. P., Jour. Pal., vol. 3, p. 46, pl. 5, figs. 4a, b, 1929.

Family ANOMALINIDAE

Genus CIBICIDES Montfort

Cibicides ripleyensis n. sp.

Plate XIX, Figs. 17-19

Description. — Test free, planoconvex, dorsal side flat, ventral face strongly convex, peripheral margin rounded, slightly lobate; chambers numerous, 8 to 9 in the last coil, last few somewhat inflated, involute on ventral side, partially evolute on dorsal face; sutures impressed, indistinct in early stages, deeper between the later chambers; wall coarsely punctate; aperture an arched opening at the periphery with a slit extending under the dorsal margin of the chambers, the overhanging edge forming a spiral groove in the umbilical area of the dorsal face. Diameter of the holotype, 0.9 mm.

Remarks. — This foraminifer bears a close resemblance to *Cibicides akneriana* (d'Orbigny), and might easily be referred to that species except for its involute ventral appearance and the peculiar character of its aperture. These features are diagnostic and differentiate the form from any other known species. It is quite similar in superficial appearance to *C. ungeriana* (d'Orbigny) and also to *C. alleni* (Plummer). The former is slightly carinate, and the latter is nearly equally convex and peripherally angulate, so that close examination precludes any possible confusion of the forms. The comparatively large size of the shells and their excellent state of preservation make them easy to recognize and should give the species excellent value for stratigraphic work.

Occurrence. — The holotype is from the Ripley at Prairie Bluff on Alabama River (Locality No. 87).

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PLATE XIX.

Figure		Page
1–4.	*Clavulina insignis* Plummer, x 28	192
	Specimens from Ripley exposure at the mouth of Boguechitto Creek, Locality No. 106.	
	1. Laterial aspect of microscopic form, showing sharp serrate angles.	
	2. Apertural view of specimen shown in Fig. 1, showing trifurcate opening.	
	3. Lateral view of megalospheric specimen.	
	4. Apertural view of specimen shown in Fig. 3.	
5, 6.	*Ventilabrella plummerae* n. sp., x 60	195
	Holotype from Ripley exposure at the mouth of Boguechitto Creek, Locality No. 106.	
	5. Lateral view, illustrating inflation of later chambers and parallelism of the margins in later stages.	
	6. Marginal view, showing long, arched aperture, and depth of chambers.	
7, 8.	*Turrilina angulata* n. sp., x 90	198
	Holotype from Red Bluff, Locality No. 105.	
	7. Side view, showing flat face and triangular form of test.	
	8. View from above, giving triangular cross-section and position of aperture.	
9–11.	*Pseudouvigerina* (?) *plummerae* Cushman, x 85	197
	Specimens from Barton's Bluff, Locality No. 53.	
	9. View showing triserial arrangement of chambers, crenulations along septae and angles, and character of aperture.	
	10. Another specimen showing side opposite from that given in Fig. 9.	
	11. View of specimen shown in Fig. 9 from above, giving cross-sectional outline of test and shape of the aperture.	

PLATE XIX.

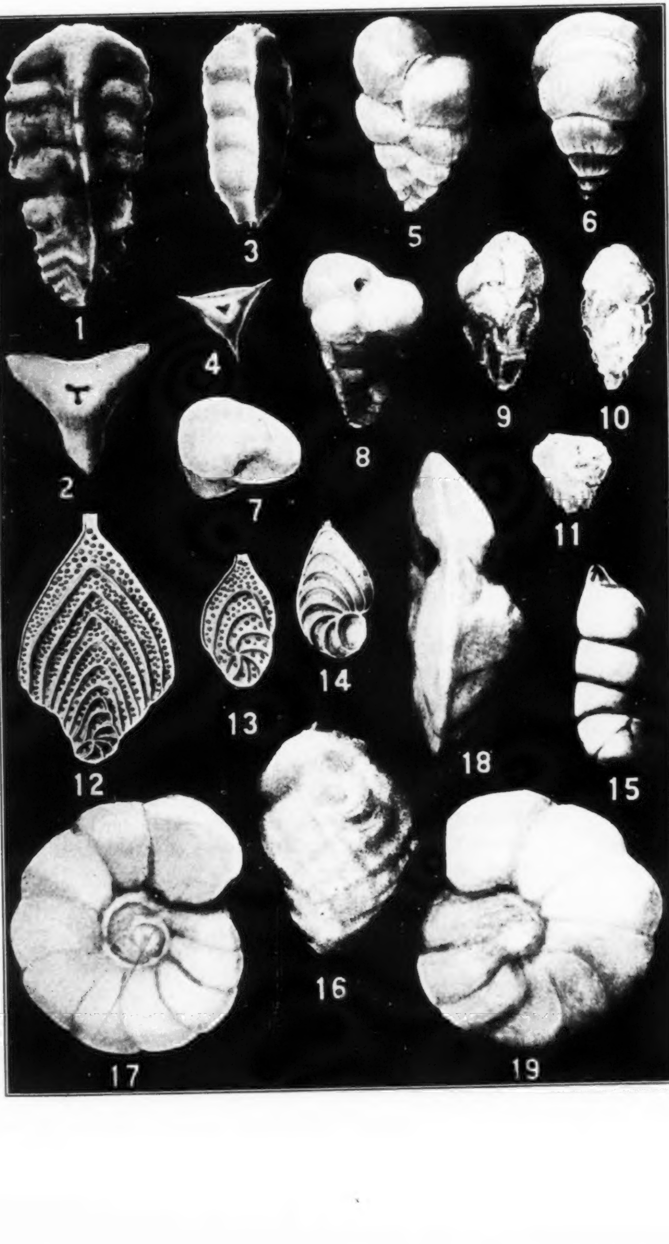

Figure | Page

12–14. *Flabellina interpunctata* (von der Marck) ---------------- 194
Specimens from exposure at the mouth of Boguechitto Creek, Locality No. 106.

12. Lateral view of adult specimen with well developed early coiled stage, x 25.
13. Side view of juvenile specimen illustrating early coiling, and first chevron-shaped chamber, x 48.
14. View of a juvenile form in an early stage of development before any chevron-shaped chambers have appeared, or in the *Vaginulina* stage, x 50.

15. *Marginulina elongata* d'Orbigny, x 42 ---------------- 194
A specimen from exposure at the mouth of Boguechitto Creek, Locality No. 106.

A representative more inflated than forms previously figured, and in an excellent state of preservation.

16. *Bolivinoides decorata* Jones, x 80 ---------------- 196
Specimen from exposure at the mouth of Boguechitto Creek, Locality No. 106.

A specimen closely approaching the original type from the Irish Cretaceous.

17–19. *Cibicides ripleyensis* n. sp., x 40 ---------------- 199
Holotype from Prairie Bluff, Locality No. 87.

17. Dorsal view showing early coils and aperture under inner edge of the last chamber.
18. Peripheral aspect, illustrating ventral convexity of tests, x 50.
19. Ventral view, showing involute character, impressed sutures, and slight inflation of later chambers.

ALATE SHELL LAMELLAE AND SPINES IN THE GENUS ATRYPA

CARROLL LANE FENTON AND MILDRED ADAMS FENTON

I. INTRODUCTION

The presence of broadly expanded or *alate* lamellae upon the shells of various members of the brachiopod genus *Atrypa* has been known for at least three-quarters of a century. Because of their infrequent preservation, however, they have been studied as exceptions, or even abnormalities, more often than as normal structures, of considerable importance in the habits, the ecological relationships, and even the evolution of the organisms possessing them. It is the object of this paper to review some of the more familiar examples of alate form in *Atrypa*, to indicate the importance of the alate lamellae in the development of spines in the genus, and to comment upon certain items of habit and ecology which may be inferred from them.

The earliest illustration of alate lamellae in *Atrypa* which has come to hand is one published by the Sandberger brothers, from a member of the *A. reticularis* group (gens?) found in the Devonian of Rhenish Prussia.[1] Nine years later, Davidson figured[2] specimens which he referred to *A. aspera* Schlotheim (including the types of *A. squamosa* Sowerby), in which fluted and apparently spinose lamellae are obvious. In 1867, the same author presented the most elaborate illustrations[3] of alate lamellae in the *A. reticularis* gens that have appeared in print. The accompanying text and plate explanation calls attention to these "foliated expansions" or "fringes," yet fails to emphasize their importance in this and other groups within the genus. The same may be said of Whiteaves' remarks

[1] Die Verstein. d. Rhein. Schicht. in Nassau, pl. 33, fig. 1, 1856.

[2] Mon. British Devonian Brachiopoda, pl. 10, figs. 5-8, 1865.

[3] Mon. British Fossil Brachiopoda (Silurian), pt. 7, pl. 14, 1867.

and illustrations[4] based on *A. "reticularis"* from the Devonian of Lakes Manitoba and Winnepegosis, although the specimen figured is second in size of lamellae only to the remarkably preserved shells and impressions occasionally found in the Devonian (Cedar Valley) at Independence, Iowa. Of these, an exceptionally fine specimen was described and illustrated by Thomas,[5] who added comments upon lamellae in members of the *A. reticularis* group. This alate individual was considered by Webster[6] to be typical of a species, *Atrypa expansa*, which we have been forced to regard as synonymous with *A. independencis* of the same author.

The first adequate statement of the prevalence of broadly expanded lamellae in *Atrypa* is that of Hall and Clarke, who remark that:

"The concentric growth-lines are bases of free squamae or lamellae, which under favorable conditions may be retained, but are usually abraded, so that the common expression of the exterior is that of an entire absence of such growths. This is the condition where the valves have been replaced by silica (a very common mode of retention), or in specimens which have been gathered from compact limestone. Under better preservation, as in soft shales or shaly limestones, the shells show the fact that the squamae of earlier growth, or those upon the umbonal and median surfaces of the valves, have been worn off during the life, or before the fossilization of the shell; the later squamae, which are stronger, broader, and more closely crowded about the margins, are those usually retained, and these are sometimes of great width, not infrequently equaling and sometimes exceeding the diameter of the valves."[7] Brief reference is given to the illustrations of Davidson and Whiteaves, and to one included by Barrande in his *Systeme Silurien*.[8] No comments are made upon lamellae in *Atrypae* of the *A. aspera-A. hystrix* type, nor upon the derivation of the spines which characterize them.

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[4] Contrib. Can. Pal., vol. 1, pt. 4, p .289, pl. 37, fig. 8, 1892.

[5] Proc. Ia. Acad. Sci., vol. 23, p. 173, pl. 5C, 1916 (?).

[6] This Journal, vol. 7, p. 15, 1921.

[7] Pal. N. Y., vol. 8, pt. 2, pp. 167-168, 1894.

[8] Systeme Silurien du Centre de la Boheme, vol. 5, pl. 19, fig. 8, 1879.

II. DISTRIBUTION AND TYPES OF LAMELLAE

A. *Atrypa marginalis* Gens

The deeply sinuate *Atrypae* typified by *A. marginalis* Dalman, of the Silurian, appear to have developed few extended or alate lamellae, although short ones commonly were present in abundance, and developed into thick, irregular layers during gerontic shell growth. For this reason, and because of the wide division between members of this gens and those of more typical groups within the genus *Atrypa*, no effort has been made to review them with care. To indicate the nature of such lamellae as are present, Davidson's figures of a gerontic *A. marginalis* from the Wenlock are reproduced. Related species from North America show essentially similar characters.

Perhaps it would be proper to separate this gens into two subgentes, one typified by *Atrypa marginalis* Dalman, the other by the related but apparently derivative species, *A. imbricata* Sowerby. The latter group consists of shells whose general shape is that of *A. marginalis*, but whose surfaces bear coarser plications and strong, complexly folded concentric lamellae. It is these, probably, which early gave rise to the confusion of these shells with such American species as *A. nodostriata* Hall, whose apparent significance in taxonomy and evolution will be discussed later. It is not clear, however, that such lamellae as are found in *A. marginalis* formed alate expansions, nor do they appear to have formed spines.

B. *Atrypa reticularis* Phratry or Gens

From their appearance in the early Silurian until they became extinct, the members of this complex, widely distributed group seem to have possessed alate lamellae of varying forms and sizes. In some species, such as *Atrypa nodostriata* Hall of the Clinton and Niagaran, and *A. reticularis* of the Waldron (Niagaran), the lamellae early became fluted and even produced into spines. In the Wenlock *Atrypae* figured by Davidson,[9] however, the lamellae are continuous and show no trace of the modification which repeatedly has produced

[9] Mon. British Fossil Brachiopoda, Silurian, pt. 7, pl. 14, figs. 1-14, 1867.

shells whose general appearance—whatever their true relationships may have been—was that of *A. aspera* Schlotheim. Several North American forms, not readily mentioned because they lack distinctive names, share with their English contemporaries in this possession of alate lamellae, or bear broken bases which indicate that such lamellae once were present.

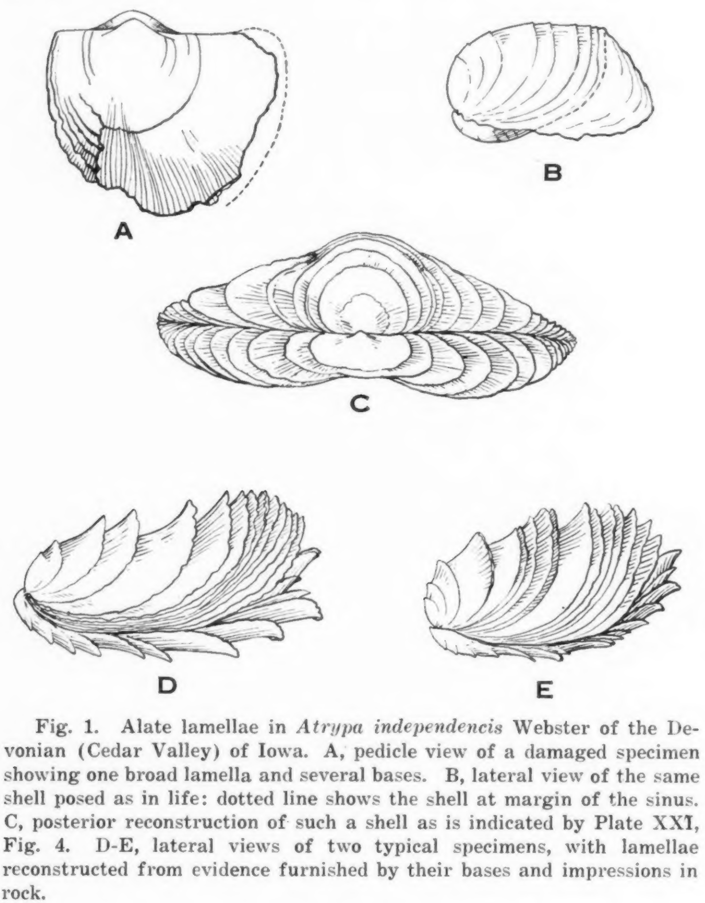

Fig. 1. Alate lamellae in *Atrypa independencis* Webster of the Devonian (Cedar Valley) of Iowa. A, pedicle view of a damaged specimen showing one broad lamella and several bases. B, lateral view of the same shell posed as in life: dotted line shows the shell at margin of the sinus. C, posterior reconstruction of such a shell as is indicated by Plate XXI, Fig. 4. D-E, lateral views of two typical specimens, with lamellae reconstructed from evidence furnished by their bases and impressions in rock.

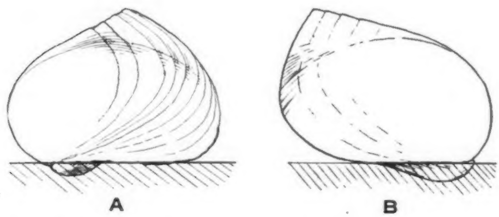

Fig. 2. Lateral views of alate, deeply sinuate *Atrypae*. A, *Atrypa trowbridgei* F. and F.; B, *Atrypa lineata* Webster, both of the Devonian (Cedar Valley) of Iowa. Shells posed in their probable positions during gerontic life.

It was in the Devonian period, however, that lamellae reached their maximal development. The extreme, among species that we have studied, is represented by *Atrypa independencis* Webster[10] of the lower Cedar Valley of Iowa, and by its relative of the Canadian Devonian. Plate XXIII, Fig. 7, reproduces Whiteaves' drawing of a highly alate shell from Manitoba, while Plate XXI, Fig. 4, gives a photograph of an impression of *A. independencis,* from Iowa. Even these fail to convey an adequate impression of the shells' appearance during life; to do this, the restoration shown in Fig. 1 have been introduced, the lamellae being reconstructed from the evidence of impressions and specimens like those of Plate XXI, Figs. 1-4 in which the bases of extension are well preserved.

Other species are close rivals. *Atrypa trowbridgei* F. and F., also of the Cedar Valley, is shown in Plate XXII, Fig. 9, as well as in Fig. 2 of the text; the specimen seems to have lost many of the lamellae of the brachial valve during life, but those of the pedicle are well preserved. As has been

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[10] This Journal, vol. 7, p. 15, 1921. *Atrypa expansa* Webster, *ibid.*, we consider to be synonymous with this species, the name having been applied to specimens in which the lamellae were well preserved. In addition to the figures on Plate XXI, the species has been figured (as *A. reticularis*) by Hall, Pal. N. Y., vol. 4, pl. 53, figs. 14-15, 1867, and by Thomas, Proc. Ia. Acad. Sci., vol. 23, pl. 5C, 1916(?).

shown in a previous paper,[11] these lamellae doubtless both contributed to a reversal of the shell's orientation, by which the pedicle valve came to lie in a ventral position, and at the same time gave it stability and aided in lifting the margins above the level of sedimentary accumulation. The large, coarsely plicate *Atrypa* which characterizes the Snyder Creek shale of Missouri probably appeared in life under spreading lamellae much like those of *A. independencis*, while even the very coarse, tumid *A. waterlooensis* Webster possessed lamellae which were thick, if not wide. We already have illustrated alate members of *A. devoniana* Webster, of the Hackberry stage;[12] their character seems typical of the species, though the lamellae may have been less extensive in compact, thick specimens, or in shells not deeply sinuate. An alate representative of one of the subspecies of *A. devoniana* is shown in Plate XXI, Fig. 5.

Devonian members of the *A. reticularis* gens show three chief types of alations. First, there are those which curve broadly and freely away from the valve, leaving—when broken away—pronounced ridges such as are seen in Plate XXI, Figs. 1-3. Second, there are relatively delicate lamellae which lie close to the general surface of the shell, and extend far beyond it only in gerontic stages, in which they become closely massed and so protect each other. Third, we find the lamellae best shown by *A. nuntia* Hall and Whitfield, of the Ohio Valley Hamilton, which bend abruptly away from the valves and so are readily destroyed. This is especially true in silicified specimens, in which removal of the lamellae is apt to leave only their rudiments, mere "lamellae of growth," upon the surface of the valve. From any of these types, but chiefly from the first and second, modifications seem to have arisen which resulted in the formation of flutings and spines, and whose multiple origins probably are

[11] This journal, vol. 13, pp. 63-74. Lamellae that would stabilize a shell resting upon its pedicle valve are illustrated by Nalivkin, Mem. du Com. Geol. (U S S R), n. s., liv. 180, pl. 8, figs. 21a-c, 1930. The specimen is from the Devonian of East Ferghana, Turkestan.

[12] Contr. Mus. Geol. Univ. Mich., vol. 1, p. 134, pl. 26, figs. 21-23, 1924.

chiefly responsible for the oft-stated opinion[13] that *A. aspera* Schlotheim, *A. hystrix* Hall, and their allies present no substantial peculiarities, and intergrade (presumably by fluctuation) with *A. reticularis.*

It does not seem necessary to present further examples of these several types of alations, nor to catalogue the forms, mostly nameless, in which they are to be found. Enough has been said to indicate that extended or alate lamellae are characteristic of many, if not most members of the *Atrypa reticularis* phratry; that they show certain peculiarities whose underlying causes probably are in some cases environmental (Buffonian) and in others, hereditary; and that they are intimately and repeatedly connected with the origin of spines in the genus *Atrypa.* No detailed survey of that connection can be given until the taxonomy, and also evolution, of the genus is at least partially unraveled.

III. THE DEVELOPMENT OF SPINES

Even though no phylogenetic summary of the development of spines from lamellae can be presented, it is possible to review the stages and modes of that development. As has been said, the many discussions of variation in *Atrypa* (discussions which generally involve forms outside the *A. imbricata* gens), in so far as they concern the origins and relationships of nodose, nodospinose and spinose forms, have little constructive to offer. In the main they reach that curious goal of futility which characterizes too many essays into speculative paleontology: an explanation of multiplicity of form by the hypothesis of non-evolutionary variation, supported by the evidence which most clearly denies it.

We already have suggested that the morphology and occurrence of these more advanced *Atrypae* suggests that they rep-

[13] See Davidson, Mon. British Fossil Brachiopoda (Silurian), pt. 7, p. 132, 1867, for instances of such confusion. Writing of *Atrypa aspera* and *A. "reticularis"* in the New York Devonian (Hamilton), however, it is notable that Hall and Clarke remark that "abundant material affords no evidence of the passage from one to the other."—Pal. N. Y., vol. 8, pt. 2, p. 170, 1894.

resent numerous lineages, each of which is marked by a development of nodes and even spines from the primitive lamellae of *reticularis*-like ancestors.[14] Although adequate evidence cannot be presented until taxonomic work has been carried much farther than it is at present, some comment may be made upon well-known forms which illustrate types and stages of this development.

Beginning with *Atrypa nodostriata* Hall, of the Clinton, and extending into the upper Devonian, we find *Atrypae* whose chief relationships are with the group currently labeled *A. reticularis,* yet whose plications and lamellae show characters generally associated with *A. aspera* and *A. hystrix. A. nodostriata* does not always show them clearly, since the specimens generally are partly exfoliated; species belonging to shaly facies are much more suitable for morphological study. One such, an outstanding Silurian form, is the *A. "reticularis"* so abundant in the Waldron formation of Indiana, whose lamellae extend in a manner which leaves little doubt that they were spinose. Especially in the smaller of the two specimens figured by Hall,[15] the lamellae are seen to project sharply and very distinctly from the plications, while the statement is made that they "are often produced and divided into subtubular short spines." Beecher and Clarke, in comparing this form to *A. rugosa* Hall, also of the Niagaran, mention that the lamellae are "infolded into nearly tubular processes sometimes produced at a strong angle from the shell to a length of a millimeter or more." [16] Such spines, of course, are delicate, and so do not generally survive the too thorough cleaning given to specimens in collections. They commonly are visible on shells from which the matrix has been but partly removed.

Devonian strata afford numerous examples of incipiently spinose *Atrypae* which are not to be derived from spinose

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[14] Paper read before the Paleontological Society, Toronto, December 30, 1930. Abstract, Bul. Geol. Soc. Am., vol. 42, p. 352, 1931.

[15] 28th Ann. Rep. N. Y. State Mus., p. 162, pl. 25, figs. 44-47, 1879.

[16] Mem. N. Y. State Mus., vol. 1, no. 1, p. 52, 1889.

Silurian forms. Plate XXIII, Fig. 3, shows a specimen from the Kalkberg of New York, in comparison with obviously spinose shells from middle and upper Devonian formations. This multiplicity of spinose and subspinose groups, appearing at various levels and in various degrees of development, in shells having different types of plications and lamellae, forms the best available evidence of polyphyletic origin and convergent differentiation. Similar polyphyly is shown by Devonian *Atrypae* of Polish Podolia.[17]

So far as can be told, the development of spines is virtually similar in all of these lineages. In those which stand closest to ancestral members of the *A. reticularis* phratry, the plications remain relatively fine and the lamellae essentially continuous. They differ from those of typically lamellose species, however, in being somewhat contracted or depressed within the furrows, and expanded and elevated upon the plications. In the early growth stages this seems to be the limit of their development in all but the most extremely spinose forms, and it probably represents normal ephebic ornamentation in subspinose species as well.

In the more highly developed stages and species, the plications coarsen and are reduced in number, while the lamellae continue to elongate upon them. The result is semi-independent extensions whose edges are downfolded so as to form tubular spines. In such species as *Atrypa rugosa* Hall and its apparent relative of the Waldron, these spines project abruptly from the body of the valve; in somewhat coarser forms, such as the one seen in Plate XXII, Figs. 4-6, they lie more nearly parallel to the surface, and marginally follow

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[17] Kozlowski, R., Palaeontologia Polonica, t. 1, *Brachiopodes Gothlandien de la Podolie Polonaise*, pp. 169-173, pl. 8, figs. 1-17; pl. 9, figs. 1-4, 1929. *Atrypa reticularis dzwinogrodensis* Kozlowski superficially resembles *A. hystrix* Hall in its fluted lamellae forming nodes (probably spinose) above the plications. *A. r. nieczlawensis* Kozlowski possesses fine plications and closely ribbed lamellae, subspinose posterolaterally, which are closely spaced anteriorly. *A. r. tajnensis* bears crowded bases of lamellae which probably met the shell at high angles, and were not spinose. It is said to "approach most closely the typical form (of the island of Gotland), but its plications are less heavy and its average size less."

each other in closely succeeding series. The extreme of spinescence is reached in such forms as *A. hystrix* Hall, *A. occidentalis* Hall and *A. rockfordensis* F. and F., in which the plications become very coarse and the spines long, with broadly elevated bases. Several European forms referred to *A. aspera* Schlotheim show similar characters.

From such extreme spinescence there comes a recession, accompanied by even greater coarsening of the plications. Some of the coarsest members of *Atrypa occidentalis* show a reduction in strength of the lamellae which support the spines, which is not wholly to be attributed to weathering or wear. Long before *A. rockfordensis* was named, Webster[18] described a form of it which he called *A. hystrix elongata* and which we regard as a derivative of *A. rockfordensis.*[19] Our choice of the adjective "aberrant" for this derivative, however, now seems unfortunate; although few specimens of *elongata* have been found, they indicate that it is a quite normal phylogerontic stage in the *A. rockfordensis* lineage. Comparing typical members of the species with the extreme form of *elongata,* and the intermediate specimen illustrated in Plate XXIII, Fig. 1, we perceive an evolutionary trend which involves reduction of both plications and spines, with a resulting relative increase in the continuity of the lamellae. It terminates, apparently, in *A. subhannibalensis* Webster,[20] of the upper (Owen) substage of the Hackberry, whose plications are few and indistinct, and whose lamellae show no trace of spines.

III. SUMMARY

It seems, therefore, that alate lamellae characterize most if not all members of the *Atrypa reticularis* group or phratry,

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[18] Am. Nat., vol. 22, p. 1104, 1888.

[19] Contrib. Mus. Geol. Univ. Mich., vol. 1, p. 144, pl. 32, figs. 5-7, 1924. The specimen illustrated is Webster's holotype; the drawings are his.

[20] This journal, vol. 7, p. 18 (*not* pl. 8, figs. 15-16), 1921; Fenton and Fenton, Contrib. Mus. Geol. Univ. Mich., vol. 1, p. 145, pl. 27, figs. 1-3, 1924. The rather unsuitable name is based on the superficial resemblance of the holotype to gerontic, lamellose specimens of *Athyris hannibalensis* (Swallow).

as Hall and other authors have indicated. Of several types, they may aid materially in interpreting the habits of their possessors, though it is not clear that they will be of much value in toxonomic study. If only because of their relatively infrequent preservation, lamellae must give way to more durable — and perhaps more fundamental — characters of shape and plications.

Spines, in the genus *Atrypa,* are derived by extension, constriction and downfolding of lamellae. These lamellae are of moderate size; so far as can be told, spines have not originated from degeneration of broadly alate lamellae. Although clearly traced lineages are not available, the presence of incipiently spinose *Atrypa* in strata whose ages range from early Silurian to late Devonian seems to show that spinescence in this, as in many other organic groups, is a convergent character of multiple origin.

The significance of neither alate lamellae nor spines, from the viewpoint of evolution, is clear. Thomas[21] has suggested that the former are phylogerontic characters, and that it is "quite possible that short lived offshoots of *Atrypa reticularis* . . . . destined to disappear, developed these encumbrances during their later stages." While this may be true in some cases, we find an argument against it in the fact that *A. independencis,* one of the most highly alate of *Atrypae,* seems to have produced a number of successful descendants, whose lamellae were much smaller than those of their ancestors. So far as present evidence indicates, it is equally probable that wide alations characterize phyloephebic or even phyloneanic species, and that racial senescence involves their reduction rather than elaboration. Between these diametrically opposed interpretations stand others, involving environmental influences of Buffonian, Lamarckian or Darwinian types. Upon these hypotheses no information at hand appears to bear.

Turning to spines, it seems clear that while they may be phylogerontic, they are not to be regarded as consequences of extreme racial senility. This interpretation, if employed at all, must be reserved for structures borne by such patently

[21] Proc. Ia. Acad. Sci., vol. 23, p. 175, 1916 (?).

degenerate forms as *Atrypa rockfordensis elongata* and *A. subhannibalensis,* in which loss of both spines and plications is obvious. Although inclining toward this latter view, we consider the data too scanty for significant decision.

Finally, we hope that these obviously preliminary notes, whose scope is limited by the paucity of described species and subspecies, will indicate the need as well as the opportunity for taxonomic, evolutionary, and biogeographic studies of *Atrypa,* one of the most prolific of Paleozoic brachiopods.

PLATE XX.

Figure

1–4. *Atrypa "reticularis"* (Linn.)

1. Pedicle valve of a young shell, showing closely spaced bases of lamellae. Enlarged. Silurian (Wenlock), England.

2. Brachial view of an ephebic shell bearing large, well-preserved lamellae. x 0.6. Silurian (Wenlock), Rushall Canal, England.

3–4. Brachial and anterior views of a specimen whose lamellae extend posteriorly. x 0.6. Silurian (Wenlock), Dudley, England.

5–9. *Atrypa imbricata* Sowerby.

5–7. Three views of a gerontic shell showing the closely spaced lamellae. x 1.3. Silurian (Wenlock), Dudley, England.

8. Enlargement of the surface, showing lamellae bending into furrows and over plications.

9. A small, coarsely lamellose shell. x 0.6. Silurian (Wenlock), Dudley, England.

10. *Atrypa marginalis* Dalman.
Anterior view of a gerontic shell showing heavy marginal lamellae. x 1.4. Silurian (Wenlock), Dudley, England.

(All figures from Davidson, Mon. British Brach., Silurian, pt. 7, pls. 14-15, 1867.)

PLATE XX.

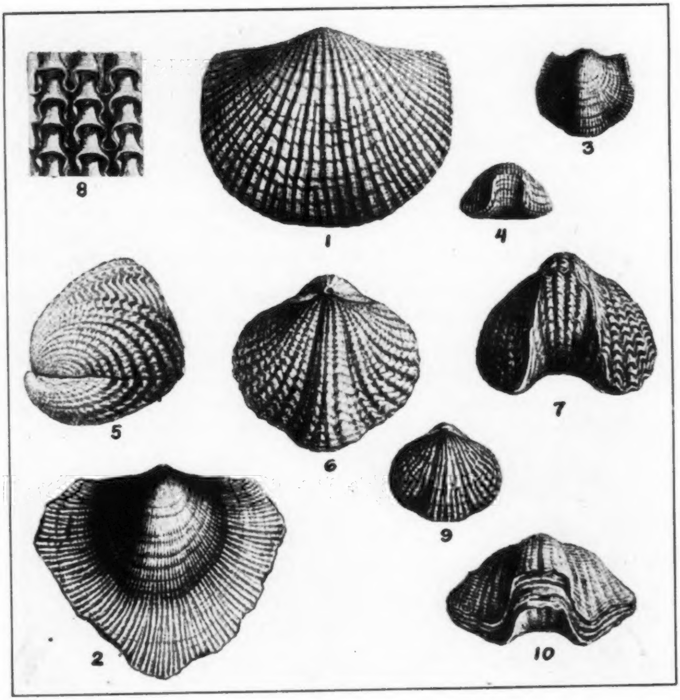


PLATE XXI.

Figure

1–4. *Atrypa independencis* Webster.

1. Brachial view of a specimen showing strong lamellar bases. Devonian (Cedar Valley), Independence, Ia. (84653 U. S. Nat. Mus.)

2–3. Pedicle view of two coarsely plicate shells bearing considerable portions of the lamellae. Devonian (Cedar Valley), Big Bend, Iowa River, near Iowa City, Ia. (84681 and 84687 U. S. Nat. Mus.)

4. Impression of a pedicle valve possessing very widely alate lamellae. Devonian (Cedar Valley), Independence, Ia. (84720 U. S. Nat. Mus.)

5. *Atrypa devoniana* Webster, form undescribed. Pedicle view of a gerontic shell bearing relatively broad lamellae. x 1.5. Devonian (Hackberry), Hackberry Grove, Ia. (84667 U. S. Nat. Mus.)

PLATE XXI.

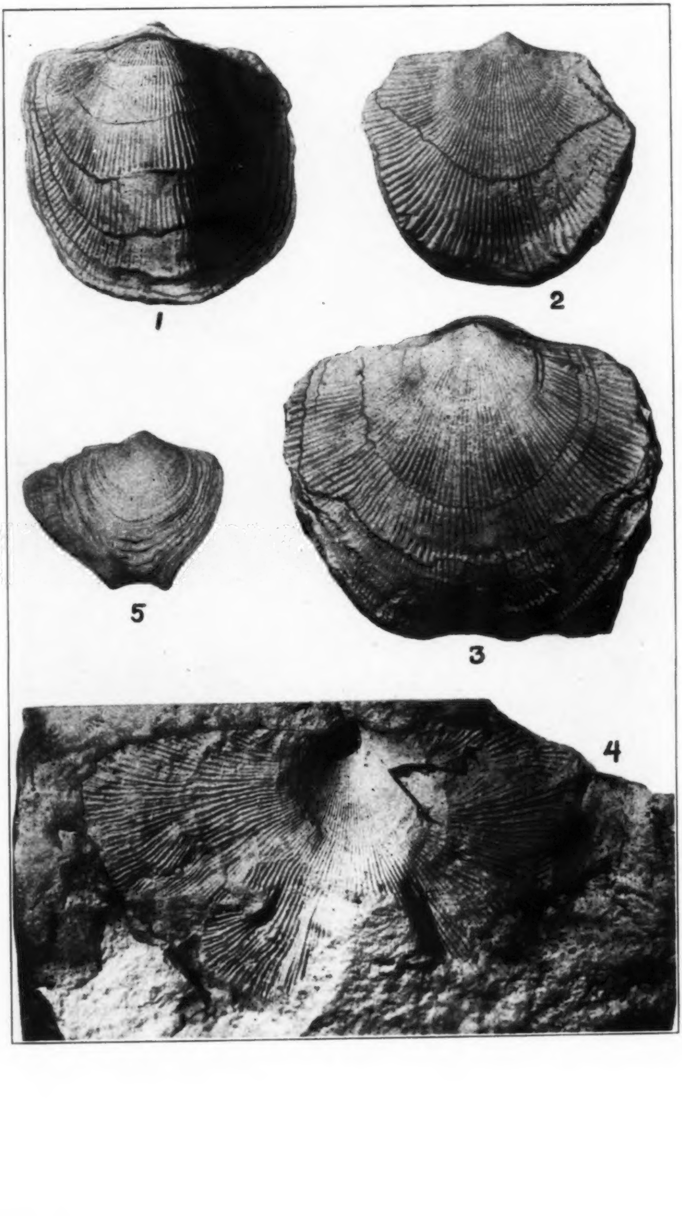


PLATE XXII.

Figure

1–2. *Atrypa* sp. Pedicle views of two small specimens of Silurian (Louisville) age, Falls of the Ohio. (4784 and 4785 Carnegie Mus.)

3–5. *Atrypa nuntia* H. & W. Pedicle views of three specimens preserving portions of the abruptly projecting lamellae. Devonian (Hamilton: Sellersburg?), Charleston, Ind. (4779-4781 Carnegie Mus.)

6. *Atrypa* sp. Brachial view of a small specimen showing traces of lamellae at relatively early stages of growth. Devonian (Cedar Valley), Waterloo, Ia. (84679 U. S. Nat. Mus.)

7–8. *Atrypa* sp. Pedicle views of two specimens preserving the bases of lamellae which seem to have resembled those of *A. nuntia*. Devonian (Cedar Valley), Waterloo, Ia. (84678 and 84677 U. S. Nat. Mus.)

9. *Atrypa trowbridgei* F. & F. Pedicle view of a gerontic, highly alate specimen of this species, whose lamellae seem to reach maximal development only in senility. Devonian (Cedar Valley), Iowa City, Ia. (84671 U. S. Nat. Mus.)

10. *Atrypa waterlooensis canadensis* Webster. Pedicle view of one of the cotypes, showing the bases of lamellae resembling those of Iowa representatives of the species of which it is a variant. Devonian, some two miles below first island below Alexandria Falls, Hay River, Canada. (78587 U. S. Nat. Mus.)

11. *Atrypa* sp. Pedicle view of a specimen, the bases of whose lamellae are expanded in a manner suggesting those of *A. aspera* or *A. hystrix*, Silurian (Louisville), Falls of the Ohio. (4786 Carnegie Mus.)

12. *Atrypa* cf. *newsomensis* Foerste. Pedicle view of a nodoplicate shell, which, though lacking lamellae, shows traces of incipient spinescence. Silurian (Osgood), Big Creek, Jefferson County, Ind.

PLATE XXII.

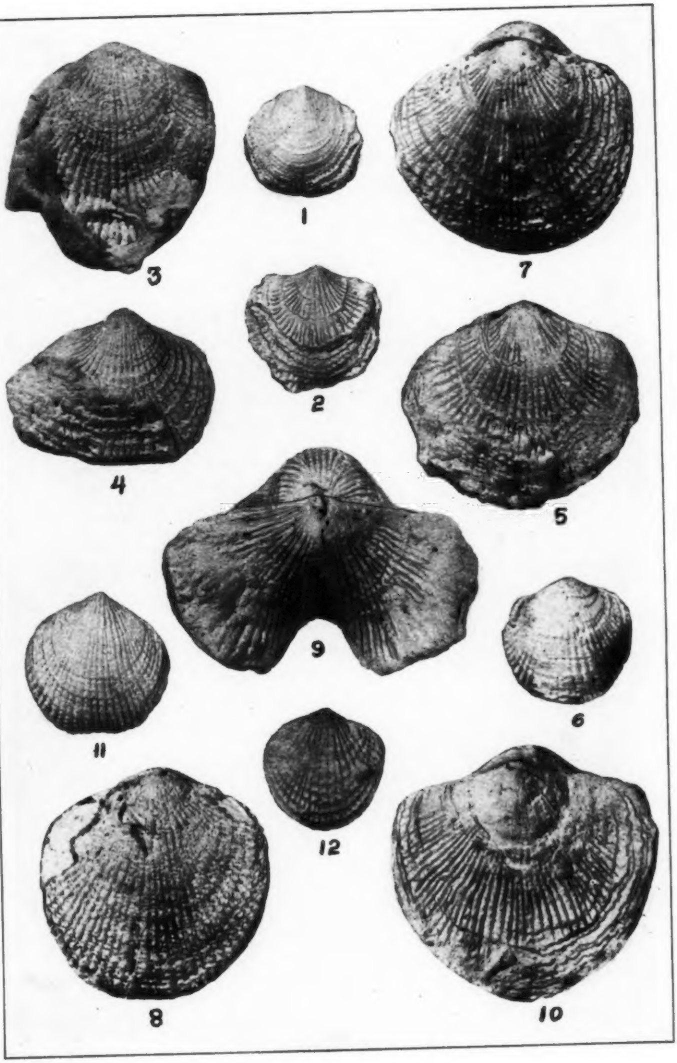


PLATE XXIII.

Figure

1. *Atrypa rockfordensis elongata* Webster, showing degenerate spinose lamellae. Devonian (Hackberry), Hackberry Grove, Ia. (4800 Carnegie Mus.)

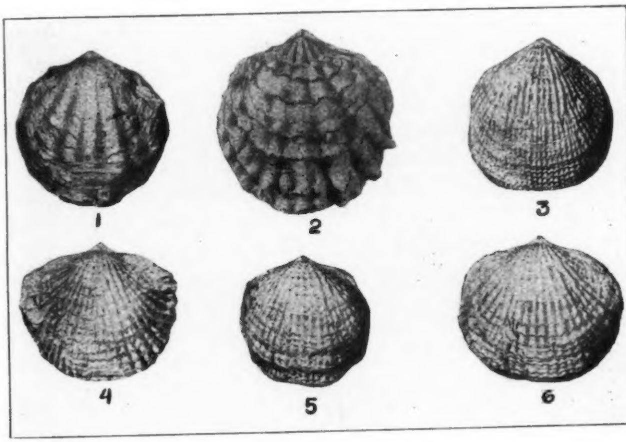
2. *Atrypa occidentalis* Hall, bearing typical coarse, spinose lamellae. Devonian (Cedar Valley), Bassett, Ia. (4801 Carnegie Mus.)

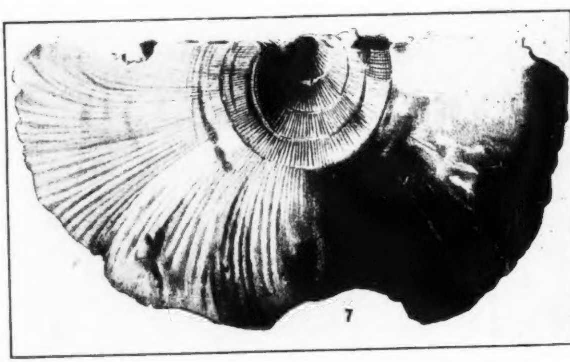
3. *Atrypa* sp., showing fine subspinose lamellae. Devonian (Kalkberg), Clarksville, N. Y. (4794 Carnegie Mus.)

4–6. *Atrypa planosulcata* Webster, var., bearing the fine closely spaced, spinose lamellae and narrow plications typical of this species. Devonian, some two miles below first island below Alexandria Falls, Hay River, Canada. (6790 Nat. Mus. Canada.)

7. *Atrypa independencis* (?) Webster, with very broad lamellae. Devonian (Stringocephalus beds), Pentamerous Point, Lake Manitoba. After Whiteaves, Contr. Can. Pal., vol. 1, pl. 37.

PLATE XXIII.





THE DEVONIAN SECTION AT SELINSGROVE JUNCTION, PENNSYLVANIA[1]

BRADFORD WILLARD

INTRODUCTION

The Selingrove Junction section is located south of the city of Sunbury, Northumberland County, in central Pennsylvania. Nearly continuous rock cuts have been made for several miles along roads and the Pennsylvania Railroad which skirt the east bank of Susquehanna River here. These are supplemented by outcrops in the river itself. The section is strategically located because it affords a key to the Devonian stratigraphy of the central part of the State and may be profitably compared with neighboring areas.

The exposures have been studied at various times, but, except for the work of the Second Pennsylvania Geological Survey, no report covers the entire section, and several of its members are practically undescribed. It seems strange that so accessible and excellent a section should have been treated inadequately and by piecemeal. Rogers[2] passed over the region with a brief note. White[3] attempted a detailed report on the section, but erred in identification and correlation of strata due to inaccurate determination of the faunas. He introduced superfluous names for the divisions which he recognized but which are readily correlated with the members of type sections having standard nomenclature. D'Invilliers,[4] working west across the river, followed White's interpretation and so only emphasized mistakes already existing. Lesley,[5] summing up the Devonian geology of the State, quoted

[1] Published with the permission of the State Geologist of Pennsylvania.

[2] Rogers, H. D., Geology of Pennsylvania (First Survey), Vol. I, 1858.

[3] White, I. C., Pennsylvania Second Geological Survey, Vol. G7, pp. 283, 343 and 361, 1883.

[4] D'Invilliers, E. V., Pennsylvania Second Geological Survey, Vol. F3, pp. 140, 155 and 157, 1891.

[5] Lesley, J. P., Pennsylvania Second Geological Survey, Summary and Final Report, Vol. II, 1892.

White's findings almost unchanged. Since 1900 several articles have appeared which clear up some of the earlier mistakes and give a better understanding of parts of the section. Williams and Kindle[6] reported on the Upper Devonian of the southern end of the area in their "Hallowing Run section." Later, Kindle,[7] alone described briefly the Onondaga of the region. An exhaustive study of the Helderberg and uppermost Silurian of the section was made by Reeside.[8] During the past two field seasons, the writer visited the section in an effort to improve our knowledge of its stratigraphy. This paper attempts to give an account of the entire section, to correct earlier errors, and to add a few new facts, especially about those members previously neglected.

THE GEOLOGIC SECTION

STRUCTURES

Figure 1 is a somewhat generalized section extending for five miles north-south along the east bank of the Susquehanna. It is important to understand the structure because, simple as it is, early mistakes in interpretation were partly due to lack of its comprehension. The literature leads one to suppose that only one anticline is present. Although White and D'Invilliers mentioned that it was doublecrested, others do not make it clear that there are two anticlines, so that it is puzzling to find one author describing the Lower Devonian and another the Upper Devonian apparently from the same structure and horizon! The two folds shall be referred to in this paper as the northern and southern anticlines. The first cut in the northern occurs about half a mile south of Shamokin Creek whence there are exposures southward for nearly a mile and a quarter. The southern anticline has its axis immediately south of the Selinsgrove Junction railroad bridge and extends therefrom about a quarter of a mile north and south. The northern fold is relatively flat. The southern anti-

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[6] Williams, H. S. and Kindle, E. M., U. S. Geol. Surv., Bull. 244, pp. 86-92, 1905.

[7] Kindle, E. M., U. S. Geol. Surv., Bull. 508, p. 31, 1912.

[8] Reeside, J. B., U. S., Geol. Surv., Prof. Paper 108K, pp. 186, 190, and 220-224, 1918.

cline is sharper, locally crumpled, and plunges 3°30′ east-northeast. The arches are separated by a syncline in turn believed to have been cut off from the southern limb of the northern axis by a fault with an estimated throw of some 200 feet.

STRATIGRAPHY

The Devonian columnar section for Selinsgrove Junction is given in the following table which is succeeded by descriptions of the characteristics of the members as recognized.

GEOLOGIC COLUMN OF THE DEVONIAN AT SELINSGROVE JUNCTION

Name	Thickness in Feet	Lithologic Character
Chemung	2000 plus	Dominantly red sandstone and shale; I. C. White's "Catskill."
Portage	1200 plus	Gray to buff sandstone and shale. Ithaca and Sherburne and perhaps Nunda divisions recognized.
Genesee	400 more or less	Black, fissile, barren shale.
Hamilton	450	Gray to buff, brown-weathering sandstone and some shale.
Marcellus	345 (?)	Black, fissile shale with bands of concretions and occasional, thin sandstone lenses.
Onondaga	70	Dark gray, non-cherty limestone.
Esopus	145	Gray, calcareous shale.
Oriskany	60 (?)	Sandstone, chert and limy shale.
Helderberg	450 more or less	Gray limestone and some dark gray shale.

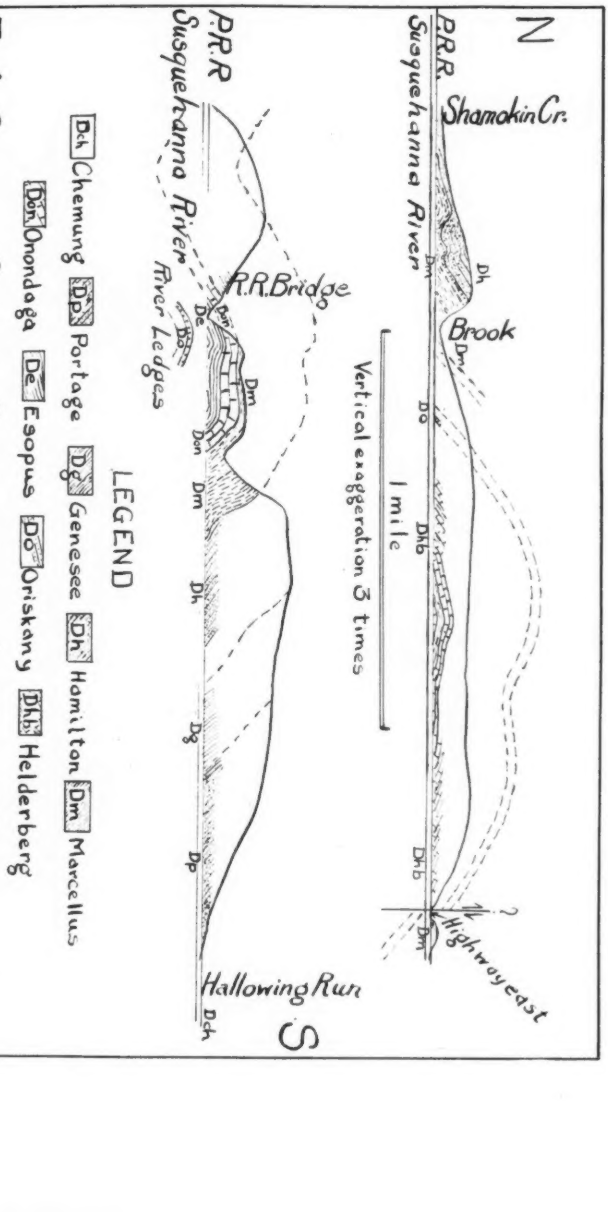

Fig. 1. GEOLOGIC SECTION, SELINSGROVE JUNCTION, PENNSYLVANIA

Helderberg. The Helderberg group (including for simplicity the Tonoloway or uppermost Silurian) is exposed only in the northern anticline along the railroad. It is over 400 feet thick, but the exact thickness is not positively known, because in the northern limb the upper part of the Helderberg is concealed, while several small faults (not shown in figure 1) of undetermined displacement cut the southern flank. In the northern anticline Reeside[9] divided the pre-Oriskany thus:

Helderberg		263.5 feet
New Scotland	57.6 feet	
Coeymans	3.6 feet	
Keyser	202.3 feet	
Tonoloway		148.4 feet
Total		411.9 feet

Reeside's work covers these members so adequately that additional discussion is superfluous. Suffice it to say that the pre-Oriskany beds are dominantly light gray, soft limestones plus occasional massive beds and considerable gray, usually limy, shale.

Oriskany. Beds assigned to the Oriskany are exposed in both anticlines and exhibit sandstone, chert and limy shale phases. They have been identified by their fossils, their stratigraphic position, or both criteria. The total thickness is close to 60 feet, but exact figures are wanting because at no place is the entire group exposed. Along the railroad in the northern limb of the northern anticline occurs a small showing of brownish sandstone and possibly some chert assigned to the Oriskany since it lies between recognized Marcellus and Helderberg, although separated from these by concealed intervals, and carries *Anopoltheca flabellites* (Conrad). The Oriskany appears to be partly faulted out at the southern end of this fold. Reeside[10] mentioned sandy limestone and shale

[9] ibid. pp. 221-224.

[10] ibid. p. 221.

beds which he assigned to the Oriskany, but it is uncertain exactly where he found them. Half a mile east of the southern end of the northern anticline along the highway is an outcrop of yellowish chert which carries *Eatonia sinuata* Hall. Beside the railroad near the axis of the southern anticline *Anoplotheca flabellites* (Conrad) again occurs in gray, limy shale assigned to the Oriskany, although lithologically these beds are more like and may be transitional with the overlying Esopus. In the river bed immediately south of the railroad bridge nine or ten concentric sandstone ridges mark the eastward plunging axis of the southern fold. These were observed during the extremely low water occasioned by the drought of the summer of 1930. Figure 2 illustrates this feature as seen from the eastern shore south of the axis of the southern anticline. The ridges are composed of from twenty to twenty-five feet of very hard, massive sandstone which carries a few poor *Spirifer* casts strongly suggestive of *Spirifer murchisoni* (Conrad). Thus, the Oriskany is the lowest member exposed

Fig. 2. Oriskany sandstone ledges in Susquehanna River south of Selinsgrove Junction railroad bridge.

in the southern anticline, but the Tonoloway appears at the base in the northern fold.

Esopus. About 145 feet of barren, light gray calcareous shale overlie the Oriskany in the southern axis, but are probably entirely concealed in the northern arch. It is well exposed along the railroad south of the bridge and also in small gullies opening east near that point. Its designation as Esopus is based upon its stratigraphic position between recognized Oriskany and Onondaga and its lack of organic remains, although lithologically it is not a grit and scarcely resembles the typical Esopus of eastern New York[11].

Onondaga. The Onondaga limestone was not identified in the northern anticline. In the southern axis it makes small, poor showings along the track, but in new cuts on the state highway (Route 14) 50 to 75 feet above the railroad level it is excellently exposed as dark, blue-gray to black limestone with some interbedded black shale. It is noteworthy that the black cherts characteristic of this member in eastern Pennsylvania and New York are lacking throughout its entire 70 feet. Fossils are scarce, Kindle listing the following[12]:

Anoplotheca acutiplicata
Chonetes cf. *hemisphericus*
Ambocoelia umbonata
Orthoceras sp.
Loxonema sp.
Octonaria stigmata and other ostracodes

Marcellus. The best exposures of the lower part of the Marcellus are along the new highway across the southern anticline; the upper part is seen where that road parallels the railroad south of Shamokin Creek. It is also observable for some distance beside the railroad in the southern limb of the southern anticline. A small, but inconsequential outcrop of the beds was recognized next south of the highway at the southern end of the northern exis where they are probably

[11] For a description of the type locality see: Goldring, E., N. Y. State Mus., Handbook 10, part 2, pp. 382-3, 1931.

[12] ibid. p. 31.

faulted down against the Helderberg or Oriskany. The beds are the uniform, fissile, black shale typical of the Marcellus throughout nearly the entire thickness of 345 feet. So far as known there are no fossils save for *Liorhynchus limitare* (Vanuxem) and *Styliolina fissurella* (Hall). Near the middle occur very hard, siderite concretions (see figure 3) a foot or two in diameter, aligned parallel to the bedding. Occasional sandstone bands one or two inches thick occur in the upper third and have been recognized in the two most remote exposures of the Marcellus in this section. At the railroad along the southern limb of the southern anticline sandy top beds of the Marcellus grade up into the Hamilton, as also in the northern limb of the northern axis south of Shamokin Creek. The most interesting exposures of the Marcellus are on the new highway across the crest of the southern anticline, above, and some 200 feet east from the railroad. These expose the Onondaga-Marcellus contact marked by about six inches of brown to olive-brown, micaceous, fine-grained sandstone resting directly upon the limestone and followed by four or five inches

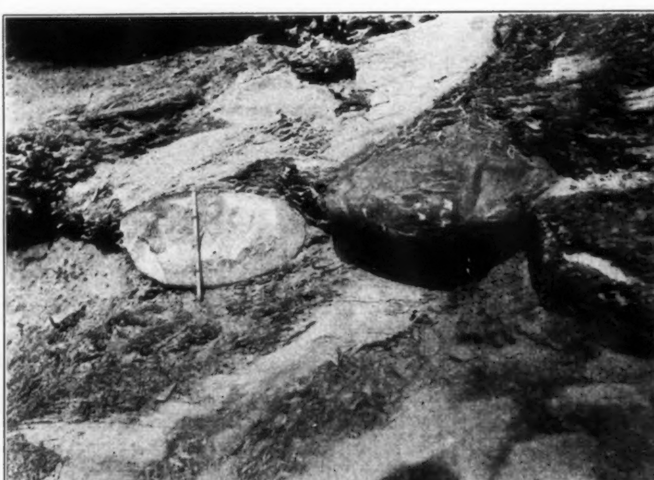

Fig. 3. Siderite concretions in the Marcellus black shale one-half mile south of Shamokin Cr. The rule is one foot long.

of gray to olive-gray shale capped by the typical black shale. A similar relation including the thin sandstone is exposed in a quarry at Half Falls Mountain on the east side of Juniata River about 20 miles north of Harrisburg. These relations are interpreted as due to a local disconformity between the Onondaga and Marcellus in central Pennsylvania.

Hamilton. Brown or gray sandstone and shale assigned to the Hamilton follow and intergrade with the underlying Marcellus, a condition recorded alsewhere in Pennsylvania[13]. Only the lower part of the Hamilton was recognized at the south side of Shamokin Creek. Along the southern flank of the southern anticline it appears beside the railroad, but the top is hidden. The thickness is probably of the order of 450 feet. From gray, shaly to flaggy, brown-weathering sandstone in the southern anticline the following faunule was collected:

Streptelasma cf. *rectum* (Hall)

Crinoidea, indet.

Bryozoa, indet.

Stropheodonta perplana (Conrad)
S. inaequistriata (Conrad)
Leptaenia rhomboidalis (Wilkens)
Chonetes scitulus Hall
C. coronatus (Conrad)
C. cf. *rugosus* Kindle
C. lepidus Hall
C. mucronatus Hall
Leptaenisca cf. *australis* Kindle
Rhipidomella vanuxemi Hall
R. leucosia (?) Hall
Camarotoechia prolifica Hall
C. congregata (Conrad)
Tropidoleptus carinatus (Conrad)
Atrypa spinosa (?) Hall
Spirifer audaculus (Conrad)
S. mucronatus (Conrad)
Ambocoelia umbonata (Conrad)
Nucleospira concinna Hall
Vitulina pustulosa (?) Hall
Athyris spiriferoides (Eaton)

Pterinea flabellum (Conrad)
Cypricardinia indentata (Conrad)

Loxonema hamiltoniae Hall

Phacops rana (Green)

Genesee. Along the railroad between the southern axis and the valley of Hallowing Run (figure 1), are poorly exposed, dominantly dark-gray to black, arenaceous, sometimes fissile, shales here assigned uncertainly to the Genesee.

[13] Willard, B., Geol. Soc. of Am., Bull., Vol. 42, p. 699, 1931.

Separated from the Hamilton by a concealed interval, its thickness is uncertain but is not less than 400 feet. Due to this concealed interval it is impossible to state if any Tully be present. Probably is occurs here, since it is known to outcrop near Catawissa some 20 miles to the east[14]. No fossils were found in the Genesee.

Portage. Along the railroad north of Hallowing Run are exposed about 1000 feet or more of strata which vary from brownish or gray, flaggy sandstone above to shalier, gray sandstone and sandy shale below and which are assigned to the Portage group. Wiliams and Kindle[15] designated approximately the lower two-fifths as Sherburne, and the upper three-fifths as Ithaca, basing their conclusions upon the enclosed fossils and lithologic differences, although there is not a sharp line of separation. The lowest 110 feet of this member, consisting of barren, sandy shale, they believed represented the Nunda. They reported the following fossils from the beds assigned by them to the Sherburne:

Cladochonus sp.
Crinoid stems
Stropheodonta (*Leptostrophia*) *interstrialis*
Schizophoria striatula
Leiorhynchus mesicastale
Reticularia laevis
Grammysia sp.
Buchiola speciosa
Palaeoneilo filosa
Leda diversa
Nucula sp.
Macrodon hamiltoniae
Modiomorpha subalata var. *chemungensis*
M. cf. *neglecta*
Pleurotomaria capillaria
Coleolus acicula
Orthoceras bebryx var. *cayuga*
Manticoceras sp.

The author was unable to rediscover the localities from which these remains came. Probably slumping has hidden them during the quarter of a century or more which has passed since Williams and Kindle collected here. From the Ithaca, Williams and Kindle reported the following assemblage:

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[14] Williams and Kindle, ibid. p. 70.

[15] ibid. pp. 88-91.

Cladochonus sp.
Cystodictya meeki
Crinoid stems
Stropheodonta (*Leptostrophia*) *interstrialis*
Chonetes scitulus
Productella hallana
P. speciosa
Schizophoria striatula
Pugnax pugnus
Cryptonella eudora
Atrypa reticularis
Cyrtina hamiltonensis
Spirifer mesistrialis
S. pennatus var. *posterus*
Spathella typica
Grammysia subarcuata
G. sp.
Palaeoneilo plana
P. sp.
Leda cf. *obscura*
Nucula corbuliformis
Macrodon sp. nov.
Pterinopectin sp.
Pterinea reproba?
Mytilarca carinata
Actinopteria epsilon
Schizodus chemungensis var. *quadrangularis*
Modiomorpha subalata var. *chemungensis*
M. subalata
Murchisonia sp.
Platyceras cf. *concinum*
Tentaculites spiculus
Coleolus acicula
Manticoceras cf. *complanatum*

To the above list the author has no new additions to make, although he was able to rediscover this faunule, at least in part. Checking these lists with that given for the Portage and its divisions in central New York[16], it seems probable that the fauna is more truly Ithaca than Enfield or highest Portage, because of the presence of such forms as *Spirifer mesistrialis* and *Pterinea reproba.* Since the beds carrying this fauna are the highest marine known in the Selinsgrove Junction section, the inferred absence of the Enfield is significant.

C h e m u n g . If the Ithaca member of the Portage is the highest marine element present in this section, the question as to the presence or absence of the Cemung confronts us. The next highest exposure, separated from the recognized Portage (Ithaca) by a concealed space of half a mile, consists of brown, chocolate-colored, or green beds. It would be interesting to know exactly what underlies the concealed interval. Comparison with the section from Catawissa to Bloomsburg east of here indicates that the Portage goes over directly into

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[16] Williams, H. S., Tarr, R. S. and Kindle, E. M., U. S. Geol. Surv., Folio 169, p. 6, 1909.

non-marine red beds. There, the Portage is nearly 700 feet thicker than the exposed part of that member north of Hallowing Run, the difference representing much of the concealed interval. Thus, a "Catskill" *type* of sediment immediately succeeds the Portage, but, assuming that no unconformity separates them, the red beds are Chemung in *age* (of course allowing for the possibility of some Enfield). Stratigrahpically, then, the Chemung is here represented by perhaps 2000 feet of dominantly red sediments. No invertebrates were found in these beds, but plant stems occur, and fish plates were collected a few miles to the east. It may be noted that to the south in Perry County, chocolate-colored beds at the base of the red series and even the red beds themselves carry Chemung marine fossils.

COMPARISONS AND CONCLUSIONS

The Selinsgrove Junction section contains representatives of most of the standard Devonian divisions of eastern North America, namely, the Helderberg, Oriskany, Esposus (?), Onondaga, Marcellus, Hamilton, Genesee (?), Portage and Chemung (non-marine facies). Some subdivisions are also recognized. Reeside divided the Helderberg into the New Scotland, Coemans and Keyser, while Williams and Kindle showed that the Sherburne, the Ithaca and possibly the Nunda are present among the Portage beds. The exposures of the Oriskany in their heterogeneous lithology suggest that the Ridgely sandstone and Shriver chert members recognized in Maryland[17], are present. Members not definitely accounted for are the Tully and Enfield. The first may be covered in the hidden Hamilton-Genesee interval, and nothing final can be said about the Enfield. Marine Chemung we observed to be absent, but this member is accounted for by continental beds formed during an early, perhaps local, incursion of the "Catskill" red beds.

Marine Chemung is recognized in northcentral Pennsylvania and eastward through Tioga and Bradford counties

[17] Maryland Geol. Surv., Lower Devonian, pp. 91-94, 1913.

where the easternmost outposts of the *Spirifer disjunctus* fauna, so far as the writer has seen, are south of Leraysville in eastern Bradford County and on Cascade Creek, Susquehanna County. Thence, southeastward through Susquehanna, Wayne, Pike and Monroe counties, nonmarine Chemung is present as red, gray-green and green sediments which accumulated during fresh-water off-lap and gave rise to such members as the Delaware River flags, the New Milford series and the Montrose red shale. In Tioga and Bradford counties the last stragglers of the *Spirifer disjunctus* fauna occur in red beds. Prosser[18] was of the opinion that there was no marine Chemung in Pike and Monroe counties, conditions substantiated by the writer's observations. In northeastern Pennsylvania the fresh-water sediments spread into the Appalachian trough in pre-Chemung, presumably late Portage, time. Marine Chemung carrying *Spirifer disjunctus* Sowerby has been discovered in Perry County 1500 to 2500 feet above the base of the red beds which are at least 4500 feet thick there.[19]. Information regarding Upper Devonian stratigraphy between Susquehanna and Delaware rivers is incomplete, but somewhere in this section the marine Chemung dies out just as it must west, northwest, and southwest of Selinsgrove Junction.

It appears that in Chemung or even earlier time continental Devonian sediments encroached on a wide front over the northeastern section of the State and reached the Selinsgrove Junction region in late Portage (presumably Enfield) time. Later these spread north and south where marine faunas survived longer than in central Pennsylvania, but eventually were driven out. Continental conditions, before the close of Devonian time, therefore, prevailed throughout the eastern third of the State.

The term "Catskill", for years applied to late Devonian red beds in eastern Pennsylvania, was, and still is, often used

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[18] Prosser, C. S., U. S. Geol. Surv., Bull. 120, 1894.

[19] It should be observed that this thickness is about two-thirds of that given by E. W. Claypole for the "Catskill" of Perry County; Pennsylvania Second Geol. Surv., Vol. F2, p. 34, 1885.

to imply strata of post-Chemung age. In Perry County, Pennsylvania, at least half of the red beds are now assignable to the Chemung; in central Pennsylvania the red sediments began to accumulate in late Portage time with no marine Chemung present; in northcentral Pennsylvania they started to form while a Chemung fauna lived in the local waters; and in the extreme northeastern corner of the State the Upper Devonian fresh-water strata are Chemnug or Portage or even older. Evidently, "Catskill" is a term best applied to a phase of continental, Devonian sedimentation of long duration rather than to a chronologically distinct group of beds. Its age in Pennsylvania may range from Portage or perhaps older through Chemung and upward perhaps even into Mississippian time since the red beds intergrade with the Pocono sandstone in the Susquahanna and Juniata valleys region. It is suggested that the name may best be restricted to signify in general the Devonian red beds of the northern Appalachians, or, in an even stricter sense, those Devonian red beds which are associated with forming of the "Catskill Delta"[20].

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[20] Barrell, J., Am. Jour. of Sc., (4), 36-37, 1913-1914.

A NEW INTERGLACIAL PULMONATE MOLLUSC FROM THE PROVINCE OF SASKATCHEWAN*

ALAN MOZLEY

Included in a collection of interglacial molluscs from the Province of Saskatchewan, submitted for identification by the Canadian Geological Survey, there is one form which appears to be worthy of special mention. This is a variety of *Lymnaea vahlii* ("Beck" Möller) which is undescribed. While the determination of the members of the family Lymnaeidae on the basis of the shell characters alone, is sometimes rather difficult, this form is sufficiently distinct to merit its description as a new subspecies. The relationships of this fossil to the other species of the genus, such as *L. palustris* (Müller), are not known, and this new form is provisionally placed under *L. vahlii* pending the completion of detailed investigations of the variation of the members of this group. The use of the generic name *Lymnaea* is retained as indicating the general relationships of these animals.

Lymnaea vahlii saskatchewanensis subsp. nov.

Shell of moderate size, about 12 mm. in length; conic; surface covered with numerous minute lines of growth, crossed by fine spiral impressed lines, of which there are from ten to twelve on the fifth whorl; whorls from five to six, convex, especially in the case of the body whorl; sutures deeply impressed; spire acute, elongated, almost acuminate, much longer than the aperture; aperture elipsiform, so somewhat diminished by the encroachment of the penultimate whorl, more or less angulated above; inner lip wide, forming a rather broad flat band which is gently curved to expose a large umbilical chink.

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Locality—Beaubier, Saskatchewan, Canada. Railway cut, southeast quarter of section 15, township 2, range 16, about 100 feet west of north-south road crossing, near Beaubier, Sask. Interglacial, exact age of deposit not given.

Type in the collection of the Geological Survey of Canada. Number 4332.

Paratypes in the same collection. Number 4332 a, b.

The distinctive feature of this new subspecies is the long slender spire. Reference to the tables given below will demonstrate this fact quite clearly. While in the case of the more or less typical form of *L. vahlii* of comparable size (Tables III and IV) the ratio of the length of the aperture to the total length of the shell is about 1.90, in *L. vahlii saskatchewanensis* this ratio is about 2.30. That is to say, the spire is a great deal longer in the new subspecies. Not only is this the case, but it holds true for all the specimens of *L. vahlii* so far examined. Comparison with the results of similar calculations based on eight hundred and four shells of *L. vahlii* from twentynine different localities (all that are to hand at the moment) shows that in not a single one of these series does the mean value for the ratio $\frac{\text{Length}}{\text{Aperture Length}}$ equal that of *L. vahlii saskatchewanensis*. In fact the mean value may be as low as 1.79. In other respects, bearing in mind the range of variation of *L. vahlii* the two forms are in close agreement.

TABLE I.

Measurements of

Lymnaea vahlii saskatchewanensis subsp. nov.

Length	Greater Diameter	Lesser Diameter	Aperture Length	Aperture Width
12.9 mm.	6.4 mm.	5.6 mm.	6.1 mm.	4.0 mm.
12.6	5.8	5.5	5.4	3.2
11.8	5.7	5.3	5.1	3.4
11.8	5.4	4.8	5.2	3.2
11.1	5.4	5.1	4.8	3.2
10.8	4.7	4.6	4.6	3.0
9.9	4.8	4.3	3.9	2.7
9.8	4.6	4.3	4.2	2.7
9 7	4.6	4.3	4.5	2.7

TABLE II.

Ratios of Dimensions in

Lymnaea vahlii saskatchewanensis subsp. nov.

	Length / Greater Diameter	Length / Aperture Length	Aperture Length / Aperture Width	Greater Diameter / Aperture Width
	2.02	2.11	1.52	1.80
	2.17	2.33	1.69	1.81
	2.07	2.31	1.50	1.68
	2.19	2.27	1.62	1.69
	2.06	2.31	1.50	1.69
	2.30	2.35	1.53	1.57
	2.06	2.54	1.44	1.78
	2.13	2.33	1.56	1.70
	2.11	2.16	1.67	1.70
Mean	2.12	2.30	1.56	1.71

TABLE III.

Measurements of *Lymnaea vahlii* ("Beck" Möller).

Locality	No.	Length	Greater Diameter	Lesser Diameter	Aperture Length	Aperture Width
Greenland (Mörch) U.S.N.M. 170217	1.	11.9 mm.	6.5 mm.	5.5 mm.	6.5 mm.	4.2 mm.
	2	10.9	6.8	5.4	5.8	3.8
St. Michaels, Alaska. U.S.N.M.60558	3	12.7	6.6	5.8	6.3	4.1
	4.	12.3	6.8	6.0	6.3	3.9
	5	11.9	6.5	5.6	6.0	3.1
	6.	11.4	6.4	5.5	6.0	4.0
	7	11.4	6.0	5.4	5.9	3.4
	8	11.1	5.9	5.2	5.5	3.4
Lake Mildred, near Jasper, Alberta.	9	12.8	6.8	5.9	7.4	4.1
Three miles west of Clair, Saskatchewan.	10	10.2	5.6	5.2	5.3	3.3
Paskwegin Brook, Saskatchewan.	11.	13.4	7.3	6.1	7.2	4.7
	12.	13.3	7.3	6.4	7.3	4.6

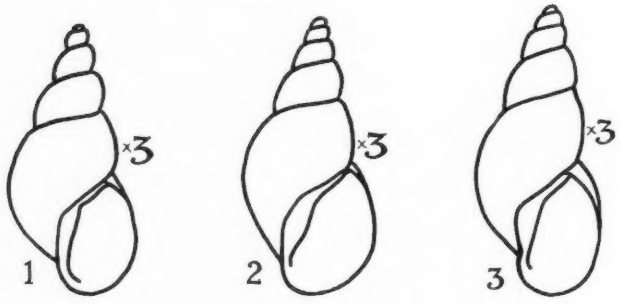
Numbers given with localities refer to specimens in the United States National Museum. Where none are given the specimens are in the collection of the author.

TABLE IV.

Ratios of Dimensions in *Lymnaea vahlii* ("Beck" Möller).

Locality	Number	Length / Greater Diameter	Length / Aperture Length	Aperture Length / Aperture Width	Greater Diameter / Aperture Width
Greenland (Mörch) U.S.N.M. 170217	1	1.83	1.83	1.55	1.55
	2	1.60	1.88	1.53	1.79
St. Michaels, Alaska U.S.N.M. 60558	3	1.92	2.02	1.54	1.61
	4	1.81	1.95	1.62	1.74
	5	1.83	1.98	1.94	2.10
	6	1.78	1.90	1.50	1.60
	7	1.90	1.93	1.74	1.76
	8	1.88	2.02	1.62	1.74
Lake Mildred, near Jasper, Alberta.	9	1.88	1.73	1.80	1.66
Three miles west of Clair, Saskatchewan.	10	1.82	1.92	1.61	1.70
Paskwegin Brook, Saskatchewan.	11	1.84	1.86	1.53	1.55
	12	1.82	1.82	1.59	1.59
Mean		1.83	1.90	1.63	1.70

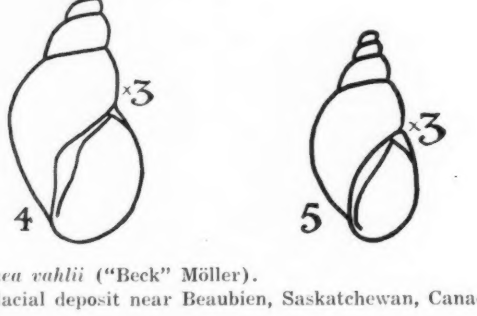
EXPLANATION OF FIGURES



Figure

1. *Lymnaea vahlii saskatchewanensis* subsp. nov. Type.
Interglacial deposit near Beaubien, Saskatchewan, Canada. National Museum of Canada, Ottawa: Holotype, Cat. No. 4332.

2, 3. *Lymnaea vahlii saskatchewanensis* subsp. nov. Paratypes.
Interglacial deposit near Beaubien, Saskatchewan, Canada. National Museum of Canada, Ottawa: Paratypes, Cat. No. 4332a, b.



4. *Lymnaea vahlii* ("Beck" Möller).
Interglacial deposit near Beaubien, Saskatchewan, Canada.

5. *Lymnaea humilis modicella* (Say).
Ninnette, Manitoba. Shell of living specimen collected by A. M. in 1924.

THE JOHNS HOPKINS UNIVERSITY.

BOOK REVIEWS

THE STORY OF LIVING THINGS, by Charles Singer. New York: Harper and Brothers, 1931. xxv + 562 pp. $5.00.

HUXLEY, PROPHET OF SCIENCE, by Houston Peterson. New York: Longmans, Green and Company, 1932. xiii + 334 pp. $3.50.

HUXLEY, by Clarence Ayres. New York: W. W. Norton Company, 1932. 254 pp. $3.00.

THE LIFE OF EDWARD JENNER, by F. Dawtrey Drewitt. New York: Longmans, Green, and Company, 1932. viii + 127 pp. $2.00.

The American edition of Dr. Singer's latest book bears an unfortunately misleading title, which suggests the current popular review of the "wonders" of biologic science. Instead (as the English edition announces) it is a history of biology written in the spirit of Dr. Singer's thesis that "the natural and proper way to survey the sciences is to treat them as arising seriatim in the course of the course of the ages from that desire which is innate in every human being to know what Nature has to reveal . . . . the sciences become records of the process of human inquiry, and science itself coextensive with the history of science. *L'histoire de la science, c'est la science meme.*"

It is not possible to review in detail a volume which ranges from the medical biology of Hippocrates to the genetic studies of Castle, Morgan and Muller. One compares it, of course, with Nordenskiöld's *History of Biology* (New York: Alfred A. Knopf, 1928), and notes that though smaller, it is perhaps even more comprehensive in viewpoint and scope. It also is more clearly organized—a great virtue in a book which is not addressed solely to biologists—and profits greatly by illustration. Such a point as the revival of scientific observation in the minor arts of the thirteenth century scarcely could be made without pictures. By contrast, quotations from the great Dominican, Albertus Magnus, fail to bring out clearly the retarding influence of literature, which led many to become mere copyists and induced even Albertus to follow second-hand translations of Aristotle almost word for word, adding his own material in the form of commentaries. Such a course was bound to minimize the great Friar's contribution, which added much to science.

The book is divided into three parts. Pages 1-118 deal with biology from Hippocrates to Harvey; 119-318, with the rise of modern from

medieval thought and the development of the thesis that the phenomena presented by living things may be treated under general laws. Leading from Francis Bacon and Descartes to the nineteenth-century Darwinians, these chapters deal with the rise of societies and journals, the influence and scope of the microscope, classification, exploration, and evolution. "With Evolution as its keynote," says Singer, "the basal arch of classical biology is completed." This sentence summarizes the attitude in which the last chapter of this section is written—though Dr. Singer makes no dogma of Darwinian evolution.

Part III deals with seven main themes of contemporary biology: the nature and relationship of the cell, the nature of life, the inter-relationships of organic processes, biogenesis, embryology, the nature and functioning of sex, and the mechanism of heredity. He stresses the fact that the so-called law of recapitulation is not to be credited to Von Baer, who did not accept organic evolution. True, Haeckel, who promulgated recapitulation, made this very error—but Haeckel always was over-willing to find anticipations of his own ideas in the work of earlier writers. What Singer himself thinks of Haeckel's law is not clear, but he seems less hostile than many biologists. Most of their objections, as I have stated elsewhere, seem based on failure to perceive the limitation of evidence and unfamiliarity with fixed exo-skeletons. The poise which marks most of Dr. Singer's pages indicates that he will avoid such pitfalls.

From this history of biology, the finest in English, we turn to biographies of two major zoologists. It is rare for a scientist to receive two full-length "lives" in a single year, even in these days of hasty biography. Nor are they apt to be based upon scientific merit—even though Huxley does appear thirteen times in Singer's index. They rest, rather, on Huxley's personality: his brilliance, his spectacular combativeness, his ability to pick on paying arguments and carry them through with *eclat.* Yet beneath this surface there was a thoroughly competent scientist, who was dangerously near to eclipse by the figure of the "bulldog of Darwin."

Both Ayres and Peterson deal with the scientific aspect of Huxley's career, even though they stress his work as publicist. Of the two, Mr. Peterson makes the better showing, since he views Huxley's career as a part of the amazing intellectual turmoil of nineteenth century Europe, not merely as that of an impassioned evolutionist. Mr. Ayres apparently takes the same position, but with less attention to Huxley's philosophical background, he presents a less satisfying picture—and one with whose expression one may sometimes quarrel. When an American author attempts to use English slang, or apply American slang to eminent Englishmen, the results are not apt to be pleasing. When Mr. Ayres tells us that Huxley was "knocked up," the reader smiles at such affectation; but to characterize one of Darwin's books as an ace shaken out of

his sleeve is an exhibition of poor taste, especially deserving of condemnation in a book whose methods ostensibly are literary.

Huxley's scientific efforts were many and varied. He considered himself a physiologist; he made major contributions to embryology, especially in his discovery of the primary germ layers. His manuals of anatomy were standard; he worked (but erred) upon fossil man. His catalogue of fossils in the Museum of Practical Geology is valuable to those who trace English types, while papers on labyrinthodonts were outgrowths of his work for the Geological Survey. In pedagogy, he sponsored such novelties as laboratory instruction, laid down principles of scientific teaching, and offered good, if forgotten advice to those who founded Johns Hopkins University. Whatever one may think of his popular essays and lectures, Huxley's scientific memoirs are a record of sound achievement which justify, if they do not explain, his election to fellowship in the Royal Society at the early age of twenty-six. The explanation, of course, lies in the relatively low standard for fellowship then prevailing, in the earnest support of the geologist Forbes, and in Huxley's own ability to get on. Huxley's passion for truth was combined with an active interest in T. H. Huxley, whose progress he knew how to advance. Both Ayres and Peterson picture him as something of an actor, and one finds no ground to question their statements.

This ability was singularly lacking in Edward Jenner, whose life also was one of turmoil. In 1873 he left London for Berkeley, having refused an appointment on Cook's expedition. Settling down in his native village, his great desire was for quiet peace, free from the trials of notoriety. He was content to treat peasants, townsmen and the local Lord, to write sentimental verse and study ornithology.

The results are matters of common knowledge. Jenner's work on the cuckoo brought forth storms of protest, while his ideas on migration differed from those accepted in his day. When he discovered vaccination all hope of quiet vanished. He aroused the enmity of believers in innoculation, offended doubting or envious physicians, and incurred the hatred of those who wished to misuse his discovery for their own profit. Jenner became an unofficial policeman of medicine in his efforts to insure the benefits of his work—and was hated in proportion to his devotion and honesty. His success, and the respect accorded him by temporal sovereigns form a remarkable chapter in practical medicine. Mr. Drewitt tells it with restraint and economy; and if his pen portrait of Jenner is less convincing than those which Ayres and Peterson present for Huxley, the difficulty lies with the subject rather than with the author's method. Surely the nineteenth century contained no more anomalous figure than a country doctor and a mature ornithologist who became a world-figure in medicine, whose wishes transcended even rules of war. — Carroll Lane Fenton.

FUNDAMENTALS OF INSECT LIFE. By C. L. Metcalf and W. P. Flint. New York. McGraw-Hill Company, 1932. xi + 581 pp. $4.00.

We commonly think of ourselves as the conquerors of nature, but the insects had taken full possession of the world millions of years before man began the attempt. They have disputed every step of our invasion of their original domain so successfully, that we can scarcely flatter ourselves that we have gained any very important advantage over them. Occasionally we may make a mutually advantageous treaty with them or even a partnership in the case of the bees and the silkworm, but wherever their interests and ours are diametrically opposed, the war goes on with neither side claiming a final victory. Yearly, they nullify the labor of one million men. We can not even protect our persons from their annoying attacks, and we have not exterminated since the war began, a single insect species. They have inflicted upon us for ages the most serious evils without us knowing it.

Buried in entomological literature is a wealth of interesting facts and observations forever lost to all but a few, unless brought together and simplified to meet the demands of the busy, modern reader. It has been the work of the authors to winnow out the choice ones, and to give us a thorough if brief treatment of the subject of entomology, combining with the less romantic facts of morphology and classification, the marvels of insect life. While at no place could their book be termed unscientific, it requires no previous biological training to read and understand it. Proportionate treatment of the economic aspects is not neglected, while the three final chapters are devoted to a discussion of the Biology and Ecology of insects from the living and the more purely physico-chemical environments, and insect behavior. This book will furnish fascinating reading any time you may pick it up. N. M. Grier.

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